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THE PANAMA CANAL. PROJETS OF THE BOARD OF CONSULTING ENGINEERS.

By General Henry L. Abbot.

General Abbot is trebly qualified to discuss his topic with authority—as one of the world's greatest specialists in the hydraulics of rivers, as admittedly the foremost student of the peculiar problems of the Chagres and the Panama Canal in its relation thereto, and as member of the Advisory Board, just dissolved. In view of the particular reasons offered by the majority of the United States Senate Committee for their recommendation of the so-called "sea-level" projet, and of the wide-spread misconception of the bearings which the San Francisco earthquake might have upon the decision in the case, General Abbot's sound analysis and comparison of the two plans is especially timely and certain to be strongly helpful in the final determination of this actively interesting question.—THE EDITORS.

THE most important consideration from an engineering point of view in projecting a transit route, whether it be a railroad or a canal is to adjust the details to the topography and natural conditions of the region to be traversed. On the Isthmus of Panama, the Chagres River is the dominating feature. The canal and river must be near neighbors for about three quarters of the entire distance, and the real problem is to so plan the former as to make it harmonize with the characteristics of the latter in the most perfect manner possible. The deep excavation in the Culebra section is a formidable undertaking, chiefly because it will be necessary to transport the spoil to long distances; but once executed it will remain without giving occasion for anxiety in the future. The Chagres, on the contrary, is capable of becoming a very active enemy at any future time unless effectively tamed by good engineering.

The Board was unable to agree upon a unanimous solution of the canal problem. Two projets were submitted, one of them at sea level

with a tidal lock at the Panama end; and the other having a summit level 85 feet above mean tide, created by a dam at Gatun and reached by three locks at that locality, the descent being made by one lock at Pedro Miguel conducting to a second lake 55 feet above mean tide, and thence to the Pacific by two locks at Sosa, near La Boca. Each projet will be briefly considered in turn.

There is no radical difference between them at the two ports of entrance, that on the Colon side being formed by a jetty skirting the shore of Manzanillo Island from a point near the mouth of the Mindi, with a short eastern jetty to suitably narrow the approach. The existing canal entrance is thus left to be used as a locus for depots of supply. On the Pacific side the existing anchorage in the Bay of Panama is reached after passing the locks by dredged channels, as heretofore. The general dimensions of both projets are controlled by the language of the law defining the size of the vessels to be accommodated, which are to be "of the largest tonnage and the greatest draft now in use, and such as may be reasonably anticipated." This requirement has largely increased the dimensions of the waterway contemplated in previous projets. The size of the commercial vessels engaged in general traffic is regulated by the depth available in the important commercial ports of the world, while that of the modern leviathans is limited only by the exceptional depths existing in the great ports between which alone they are designed to ply. The capacity of the new projets thus not only greatly exceeds that afforded by any existing ship canal, but also largely discounts future demands for increased facilities.

Both these projets also differ in another important element from those which have preceded them. The cut at the Culebra section, below the top of the indurated argillaceous schist, is projected by the board on a general slope of 3 on 2 instead of 1 on 1 as adopted both by the New Panama Canal Company and by the Isthmian Canal Commission of 1899-01. This considerably reduces the estimated volume of the excavation, especially for the sea-level projet. Whether the nature of the material will justify so steep a slope in the deep cut is left to be verified in prosecuting the work.

The sea-level projet.—The waterway through the land section is given a depth of 40 feet below mean tide, with a bottom width in earth of 150 feet and side slopes adjusted to the nature of the ground so as to give a surface width varying between 302 and 437 feet. In rock the bottom width is to be 200 feet, and the surface width 208 feet. The least cross section thus slightly exceeds 8,000 square feet. Of the

total length of 49.14 miles between deep water in the two oceans, 20.39 miles are to have a bottom width of 150 feet, and 19.47 miles a bottom width of 200 feet.

The curvature throughout is gentle, but for 19 miles a large ship must continuously be changing direction in a channel having a width only from one-quarter to one-fifth of her own length, and which as will appear below may carry currents of about four feet per second. Such a waterway is far from meeting the conception of free and unobstructed passage popularly associated with a sea-level canal.

The total volume to be excavated is estimated at about 231 million cubic yards; and the average cost including all kinds of material at all levels is figured at about 80 cents per cubic yard. It should be stated, however, that this estimate is considerably increased by the Isthmian Canal Commission in transmitting the Report. The total cost of the projet is placed by the signers at 247 million dollars, and by the Commission at 272 millions. The time required to build the canal is estimated by the former at twelve to thirteen years, and by the latter at not less than twenty years.

It remains to consider how the problem of regulating the Chagres River is solved in this projet. During construction numerous temporary diversion channels are recognized as unavoidable, but as many of them will be subject only occasionally to a considerable flow, and as the constant outlay to keep them free from the invasion of the rank tropical growth would be large, most of them are ultimately to be abandoned. The canal itself is to become the channel through which by far the greater part of the volume of the Chagres must reach the sea. The de Lesseps idea of a still water canal is thus replaced by a regulated river, in which a maximum velocity of about four feet per second at times may be tolerated. The means by which this design is to be effected are the following.

The Chagres River where it first strikes the line of the canal near Gamboa carries about two-thirds of its entire volume at Bohio, which in the flood of 1879 was about 112,000 cubic feet per second. This portion, nearly 80,000 cubic feet per second, is to be arrested by an immense dam at Gamboa rising 180 feet above the surface of the canal, distant only about a quarter of a mile. The total length of the crest would be about 6,000 feet, of which 1,000 feet would rise from a level 50 feet below the bed of the river, the excavation being in very permeable sand and gravel. No detailed design for this dam was formulated, and even whether it should be an all masonry structure or a concrete core wall bedded in an embankment formed from the spoil

of the Culebra cut was left for future determination. Surveys above the site indicate that the capacity of the lake thus formed would be ample to arrest the largest known flood, and by a system of sluices it is proposed to admit the accumulated volume gradually into the canal at a rate not exceeding 15,000 cubic feet per second. Whether the volume would flow to the Atlantic or through the Culebra cut to the Pacific, or partly by each route, would be determined by the contributions received at the time from the lower tributaries.

The regulation of the tributaries entering the Chagres below Gamboa is not so simple. Those nearest to the Atlantic are the Trinidad and the Gatuncillo. The former is to be confined to the old bed of the Chagres by protection levees bordering the canal for about eight miles above Gatun; the latter, with the other tributaries of the right bank below Bohio, is to be diverted by embankments near Gatun into the unfinished French diversion channel conducting to Manzanillo Bay. Above Bohio the problem becomes more difficult. The volume to be disposed of aggregates about one-third of the total present discharge at Bohio, which in floods may equal 35,000 cubic feet per second—enough to raise the existing river 23 feet at the low stage. The three most important tributaries on the left bank in this district are the Cano, the Gigante, and the Gigantito, all of which enter below Tavernilla. Their contributions are to be held back by four dams, forming two great lakes raised to sufficient heights to admit of drainage near their headwaters, one to Pena Blanca swamp and the other to the Trinidad river, both thus augmenting the volume acting against the canal levees. It is to be noted that time did not admit of detailed surveys for these dams, so that the estimates of cost are based on suppositions. From the best maps available the height above ground of the three largest was assumed to be about 70 or 80 feet, and the aggregate length about 3,500 feet. They were assumed to be of earth.

But these three rivers do not comprise the only important tributaries between Gamboa and Bohio. There are fifteen others which during the nine rainy months are liable at any time to carry considerable volumes, to say nothing of the small drainage channels abounding in a region subjected at this season to a rainfall of over a dozen inches per month. This volume, including the entire contributions from the right bank and all above Tavernilla on the left bank, is to be turned into the canal, causing with that received at Gamboa from the lake, cross currents, possible erosion of banks, and more or less deposition of sedimentary matter to be removed from time to time by

dredging. In the Report the maximum velocity of the current in the canal is placed at 2.64 miles per hour, or about 4 feet per second.

Such a route with 19 miles of continuous change of direction, and the difficulties of passing each other superadded, will not be attractive to modern leviathans. The more the problem is studied of how to adjust a sea-level canal to the Chagres River the more difficult does it appear. It is well to recall that since the de Lesseps fiasco the question of the best type of canal has been brought officially before three foreign and one American engineer Commissions, aggregating thirty-nine members, to whom should be added M. Choron, the eminent chief engineer of the New French Company, and that without a dissenting voice the decision has been in favor of the lock type. If the fanciful dream of an unobstructed waterway is to be met the only alternative appears to be to incur the expense of untold milions in opening a "strait" across the Isthmus, and in depriving the present generation of any benefit arising from its construction. The sea-level canal as projected differs widely from such a conception.

But this projet for a sea-level canal does not dispense with a tidal lock. At the Pacific entrance to the canal spring tides have two daily oscillations of about 20 feet, and it was the unanimous judgment of the Board of Consulting Engineers that a tidal lock in duplicate could not prudently be avoided. To admit such tidal waves into a canal already carrying currents was not seriously to be considered. Locks were accordingly projected at a favorable site between Mont Ancon and Mont Sosa, having a serviceable length of 1,000 feet and a serviceable width of 100 feet. It has been claimed that the gates can stand open when the difference between the water level in the canal and in the Bay of Panama does not differ more than a few feet and hence that such locks will be much less of an obstruction to traffic than those of the normal type. Actual experience at the eastern entrance of the Kiel canal does not warrant this claim. There the usual tidal oscillation does not exceed a foot or two, but in wind storms the level may rise about 10 feet or fall about 8 feet in respect to the normal stand, and it was decided that locks could not be avoided. It was however estimated that they would stand open about 330 days in the year. Actual trial has demonstrated the error of this assumption. Even gentle currents have been found to be dangerous to shipping attempting to pass between the lock walls (82 feet apart), and the regulations now require the gates to be kept closed. Evidently, as is contemplated by the projet, a sea-level canal at Panama must be obstructed by a tidal lock at the Pacific entrance; and what

may happen at the Atlantic entrance during the rare occasions of the violent tempests known as "northers" is a matter of conjecture. A great tidal wave entering a sea-level canal under such circumstances may work serious damage both to shipping in transit and to the earthen side walls of the canal itself.

The lock canal projet.—The waterway of this type, as projected, has strong points of resemblance to that between Lake Superior and Lake Huron, which now carries more than three times the tonnage passing the Suez Canal, and more than the aggregate passing the four great ship canals of the world—the Suez, the North Sea, the Kiel, and the Manchester. The Poe lock alone in September and October, 1905, when the Board was in session, passed 6,622,239 net registered tons. This great St. Mary's waterway has a total length of about 61 miles. The difference of level between the lakes is about 22 feet, of which 20 feet are concentrated at the Sault Ste Marie. This height is overcome by either one of three locks, which were built in the following order; the Weitzel, having a length of 515 feet and a serviceable width of 60 feet; the Canadian, having a length of 900 feet and a width of 60 feet; and the Poe, having a length of 800 feet and a width of 100 feet. It is proposed to replace the Weitzel lock by a new one having a length of some 1,300 or 1,400 feet and a width of some 75 or 80 feet. The canals proper on both sides of the river are simply approaches to the locks from Lake Superior, the length of each being about 1.5 miles. The rest of the waterway is an improved natural extension of Lake Huron, soon to have channels of a minimum width of 300 feet where used by shipping moving in one direction only, and a width from 600 to 1,500 feet where traversed by shipping moving in both directions. The present depth is nearly 21 feet, soon to be increased to 25 feet.

The lock projet for the Panama Canal contemplates a navigable waterway of this general type, which affords accommodation vastly superior to any that can be constructed in excavation at this locality at any reasonable cost and in any reasonable time. Instead of a relatively narrow channel more or less affected by currents, bank erosion, and sedimentary deposits, unrestricted lake navigation is afforded through a channel never less than 1,000 feet wide for one-third of the entire route. The rest of the distance, except for five miles at the Culebra cut, affords a channel ranging from 800 to 300 feet in width and nowhere subjected even to gentle currents, except for about 4 miles below Obispo in great floods; and even here they will be eliminated when the time comes to build the Alhajuela dam.

Throughout the entire waterway, including the Culebra cut, the normal depth is 45 feet, ranging from 47 to 42 feet according to the stand of the lake, which will never fall below the normal except during the latter part of the three dry months, February, March and April. The Chagres River is simply and effectively controlled, being received with all its tributaries in an immense lake where all currents will be naturally absorbed and where any deposits will be made far from the route for shipping. This liberal increase in sailing width and depth, and freedom from currents and deposits, will offer attractions to mariners far out-balancing the objection of having to pass a few locks.

The size of the locks has been determined by the language of the law authorizing the canal. The largest ships now existing or under construction are the Mauritania and the Lusitania of the Cunard line, which are 800 feet in length, 88 feet in beam, and 38 feet in draft at the maximum load line. A length of 700 feet and beam of 76 feet may be accepted as the dimensions of the largest commercial ships now in use or building that are likely to traverse the canal. The locks are designed to afford a serviceable length of 900 feet and a serviceable width of 95 feet. With a view to absolute security of operation, the projet provides two pairs of gates at the head and two at the foot of each summit-level lock, together with long approach piers and other devices to guard against all possible contingencies; although experience at the St. Mary's Falls canal, where a traffic of 360 million tons net register has passed during the past fifty years without a single accident seriously obstructing navigation, demonstrates how little they are to be feared either for the canal or for the shipping. The chances are as nothing compared with the risks every where encountered from storms on the ocean or in passenger and freight movements by railroad.

The lake forming the summit level, 85 feet above tide, is created by an earthern dam at Gatun, to which unprecedented dimensions have been given in order to place its safety beyond cavil. Its location near the coast, where the valley of the Chagres for a dozen miles rises very gradually above sea level, favors the formation of a deep lake by a dam of moderate height. A water level of 85 feet at Gatun floods an area of about 110 square miles, affording an enormous reserve for canal operation in the dry season; while at Gamboa the dam must raise a lake 130 feet above the bed of the stream to flood about 33 square miles. At Gatun the dam will rest on a formation of rocky impermeable indurated clay, traversed by two ancient gorges

now filled by deposits of the tertiary period. In the larger, this deposit consists of a practically impermeable mixture of fine clay and sand extending to a depth of about 200 feet below mean tide, the width at top being about 1,800 feet and at bottom about 900 feet narrowing to about 100 feet. The cross section is about 25,000 feet and the borings show no really permeable material. The smaller gorge is 900 feet wide at top, and is filled with similar material to a depth of about 200 feet below tide. The remaining 60 feet contains a stratum of coarser material which may permit moderate seepage; it has a width at top of about 400 or 500 feet, narrowing to a point at bottom. This dubious material has a cross section of about 15,000 square feet. No imaginable percolation through such material as this is, and at such depth, could endanger the safety of an earthern dam properly planned; and any loss of the low-water reserves can, if deemed advisable, be prevented by the familiar process of pumping down cement grout. Furthermore, if it should be thought expedient to do so, by the use of modern sheet piling and other well-known devices all possibility of sensible seepage can be eliminated. The entire question is simply one of engineering detail to be solved by the chief engineer when the time comes to construct the dam. By far the larger portion rests on ideal foundations.

The only other dams of any importance in the lock canal projet are the three on the Pacific coast to form the small lake at that end of the canal. They are to be of earth, like that at Gatun, and call for no special discussion. Indeed if, as suggested by Mr. Stevens, the tidal lock be placed at Miraflores, as was done in the earlier projets, these dams will not be called for.

The exceptional size of the locks gave special importance to the study of the water supply available during the three dry months; but the ample data collected by the engineers of the French companies, supplemented by measurements made on the Trinidad and the Gatuncillo by the Isthmian Canal Commission of 1899-01, fortunately left no element in doubt. The area of the basin of the Chagres above Bohio is about 700 square miles, and above Gatun about 1,200 square miles. The corresponding lake areas are to be 38.5 square miles and about 110 square miles. The extended series of water measurements conducted at Bohio for fifteen years have made known the volume that the river may be depended on to contribute during the three dry months when the natural flow falls below the requirements of the canal. The absolute minimum volume during this long period was 742 cubic feet per second at Bohio and about 1,225 cubic feet at Gatun.

Allowing 4 feet in depth over the entire lake surface as a reserve, we have an additional volume of 1,577 cubic feet per second available, affording a total of 2,802 cubic feet per second to draw upon. Part of this must be allowed for unavoidable losses from evaporation, infiltration, leakage at gates, power for lighting the canal and operating the locks, etc. Based upon a careful study of all existing data this volume is estimated at 1,437 cubic feet per second. The difference between 2,802 and 1,437—that is to say 1,365 cubic feet per second—represents the volume which can be expended during the three dry months in lockages. The size and lifts of the lock being known, a little calculation indicates a continuous flow of 52 cubic feet per second as that required to supply the prisms for one transit of the canal. Having 1,365 cubic feet available, 26 daily transits are thus provided for, which would accommodate from 30 to 40 million tons of annual traffic, depending on the size of the vessels. When this limit is approaching it will be needful to provide a dam on the upper Chagres for additional reserves. An ideal location exists at Alhajuela, some ten miles above Gamboa, which is vastly preferable to the latter as a dam site. A design was carefully elaborated by the engineers of the French Company, of which the cost was estimated at $2,400,000. With a water surface rising 130 feet above the bed of the river, this masonry dam will collect a reserve during the rainy months sufficient to yield a flow of 2,074 cubic feet per second for the ninety days of the dry season, which will support 40 daily lockages. Obviously there can never be a deficiency of water for any conceivable traffic demands, and by providing additional locks future generations can increase the passage capacity of the transit route to any desired extent.

It remains to consider the dangers which have been urged against the canal, especially one of the lock type. Fanciful speculations have been advanced suggesting attempts to interrupt navigation either maliciously or in time of war. They seem to be wholly uncalled for. We stand pledged to open the route to the commerce of the world, and by adopting the policy of international agreement to its neutrality, so successful at Suez, all danger of its becoming a battlefield will be eliminated. It is conceivable, however, that in the event of a passage of a fleet of battleships in time of war the hostile nation might plot its interruption, and it is therefore pertinent to consider the relative dangers of such attempts directed against a sea-level and a lock canal. The most vulnerable points are not the locks, sluiceways, and dams, for these occupy but little space and can easily be guarded by a small force. The most ready point of attack would be where a narrow

waterway traverses a jungle, favoring the placing of a bag of dynamite where the ship must certainly pass, and where its explosion could be effected either by an automatic mechanical device or by a man concealed in the undergrowth, where he would be little exposed to detection by patrols and where he could operate a portable electric igniter. Such places abound on the long and narrow route of the sea-level projet, but are rare and easily watched on the relatively broad lake route. The risk is distinctly greater for the former than for the latter.

Another danger, perhaps unduly magnified at the present time, is that due to a possible earthquake. Fortunately the Panama route traverses a region less exposed to such dangers than any other on the Pacific slope. It lies about midway between the long line of volcanoes extending southward from Colombia and northward from Costa Rica. The latest eruptive rocks of the Isthmus date from the early tertiary period, and what earth tremors are experienced are those transmitted from distant foci of disturbance. That destructive shocks are very rare is attested by the wide flat arch in the old Santo Domingo convent at Panama, which has stood uninjured since the early days of this ancient city. As a measure of the relative danger, it may be noted that seismograph records kept recently for the same forty-four consecutive months at Panama and San Jose de Costa Rica, show four slight shocks lasting ten seconds at the former, and ninety-one slight and thirty-five strong shocks lasting sixteen minutes at the latter. A really formidable earthquake might disturb the adjustments of lock gates, but could hardly effect such an artificial hill as forms the projected dam at Gatun. What it would do to a dam rising nearly 200 feet above its foundations at Gamboa, and sustaining the pressure it may be of a head of 130 feet of water behind it, is not so certain. A failure of this dam from any cause, or indeed of any one of the three high dams on the left bank, would overwhelm a sea-level canal with a flood compared with which the disaster at Johnstown would be as nothing.

It is proper in closing to remark that the details of the projets under consideration were elaborated by a study of only about three months, while those of the two antedating them had received years. For the lock projet, especially, there may be several variants conforming to one general design. Indeed, an examination of these three projets indicates that properly they all may be so considered. For example, the fundamental element which determines the depth of the great cut is the level above tide of the *bottom*, not of the *water*

surface, of the summit level of the canal. This height was assumed by the French Company at 32 feet, by the Isthmian Canal Commission of 1899-01 at 47 feet, and by the Board of Consulting Engineers at 40 feet. So small differences tend to confirm the belief that the general elements have received the attention requisite to develop wise conclusions, and that actual construction may be actively pressed without fear of radical changes hereafter. Meantime it would be well to consider minor variants, such as that mentioned above suggested by Mr. Stevens.

A brief comparison of the last and the earlier projets may be suggestive. One of its undoubted merits is the extension of the lake to cover the valley below Bohio. This eliminates two objections to the Commission projet—lifts of 45 feet at Bohio, and the excessive volume discharged upon the district below where the canal was to be at sea-level. It improves the French projet by doing away with the extensive use of regulated spillways and of the necessity of two lakes to control the floods—thus largely increasing the capacity of lake Alhajuela for low-water reserves. Incidentally it renders of no importance the fact that the lock site at Bohio is too short to accommodate two locks in flight having the dimensions called for by Congress.

In view of the vigorous attacks that have been made upon the dam and three locks in flight at Gatun, attention may be invited to the fact that small changes are here possible. By transferring the upper lock to Bohio the flight at Gatun will be reduced to two locks, and the height and dimensions of the dam will be greatly reduced. At the Bohio site there is ample space for a single lock, and a dam there raising the lake above to 85 feet will retain all the advantages of the Board projet from that point to the Pacific. The lift will be only about 25 feet, and the counter pressure of the lake below will render seepage under the dam of no importance. Indeed it may easily be eliminated if so desired by familiar methods. The only objection to this modification will be a reduction of storage space for the low-water supply, but computations demonstrate that this may be met practically by an earlier construction of the Alhajuela dam. Another possible variant, which would however involve an increased cost of construction, would be to reduce the summit level to about 65 feet, with one lock at Gatun and another at Bohio, the descent being made by three locks as in the projet of the French Company. This would still retain the advantages of the lake below Bohio, raised to a height of about 33 feet only. In a word, the lock solution admits of several variants by which any criticisms raised against the Board projet may be readily met if desired.

EARLIER AND MODERN WET-GRINDING MACHINES AND PRACTICE.

By H. F. Noyes.

THE ENGINEERING MAGAZINE was early to recognize the importance of the grinding machine, and the part it was to play in the profitable specialization of metal cutting. It is not the supplanter, but the most useful coadjutor, of the older forms of machine tool. Two years ago we presented a very interesting article on the subject, by Mr. C. H. Norton, dealing principally with the character of the work turned out and the action of the cutting wheel. Mr. Noyes takes the matter up from the point of view of mechanical development and working practice. —THE EDITORS.

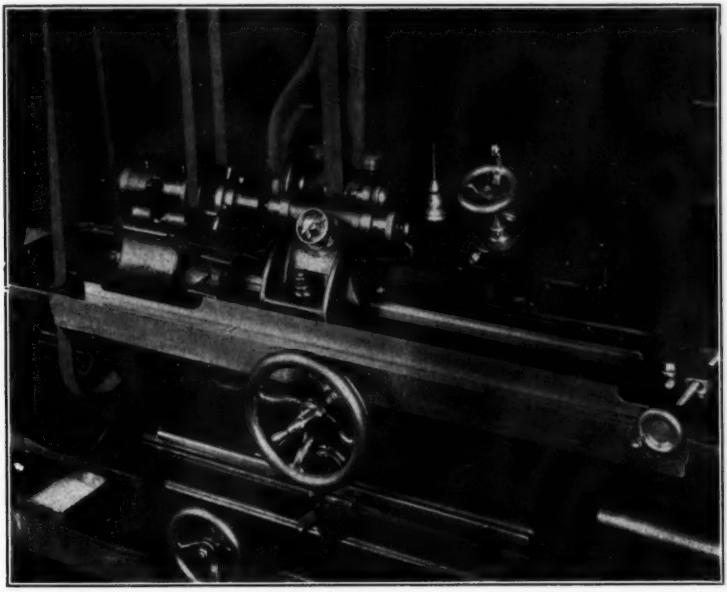
THE practice of commercial wet grinding has changed so materially within the past few years, both in the design of machines and, incidentally, in the quantity and quality of work turned out, that what was considered good performance five or six years ago is wholly obsolete now.

The grinding machine is a finishing machine, its business being to finish, to whatever limits are desired, work which has been previously turned to within about 1/32 of an inch of the desired size. The limits vary according to the requirements and size of the work from one-eighth of .001 inch in small and delicate work to .001 inch or .002 inch on large work such as engine parts; therefore the grinding machine must be the most accurate of all our machine tools.

The purchasing agent of today, who is looking for a wet cylindrical-grinding machine, is practically confined to three makes, The Norton Grinding Co., Worcester, Mass.; The Landis Tool Co., Waynesboro, Pa.; and The Brown & Sharpe Mfg. Co., Providence, R. I.

Of these firms, the Brown & Sharpe Mfg. Co. is the oldest and as early as 1876 had machines on the market. The original inventor of the universal grinding machine was Mr. S. R. Brown, one of the founders of the Brown & Sharpe Co., and one of his patents issued in 1877 shows most of the elemental features found in the machines of today. The use of a swivel headstock on a swivel table was one of his inventions, and his patent controlled the use of this device until its expiration.

The earlier machines of this class were designed by Mr. E. H. Parks, for many years an engineer with this company, and the



THE FIRST LANDIS GRINDING MACHINE. 1886.

later ones by Mr. C. H. Norton, now of the Norton Grinding Co., who designed the first Brown & Sharpe plain machines.

The second to enter the field of grinding machinery was the Landis Tool Co., at that time as Landis Bros., with machines which were the inventions and design of Mr. A. B. Landis. His first machine, which is here illustrated, was built in 1886 at the shops of the Geiser Co., Waynesboro, Pa., where he was then employed; and this machine is today running at their plant. It is a matter of interest that it practically had its inception through the refusal of the superintendent to get for Mr. Landis a Brown & Sharpe machine which he wanted for the tool room.

The distinctive characteristic of this machine, which has been carried through all the machines of Mr Landis' design, is the idea of traversing the grinding wheel longitudinally of the work, in distinction from traversing the work.

The third to enter the field was the Norton Grinding Machine Co., with machines from the designs of Mr. C. H. Norton, also of the Norton Emery Wheel Co., who had previously been identified with this line of work with the Brown & Sharpe Co.; and while this

is the youngest company of the three, their machines show some of the most advanced practice and Mr. Norton has long been recognized as a pioneer in grinding-wheel manufacture and practice.

In tracing the development of these machines, which has taken place along much the same lines as other machine tools, no radical changes appear. It has been a step-by-step process, each step in the direction of getting out a little more or a little better work in the same time.

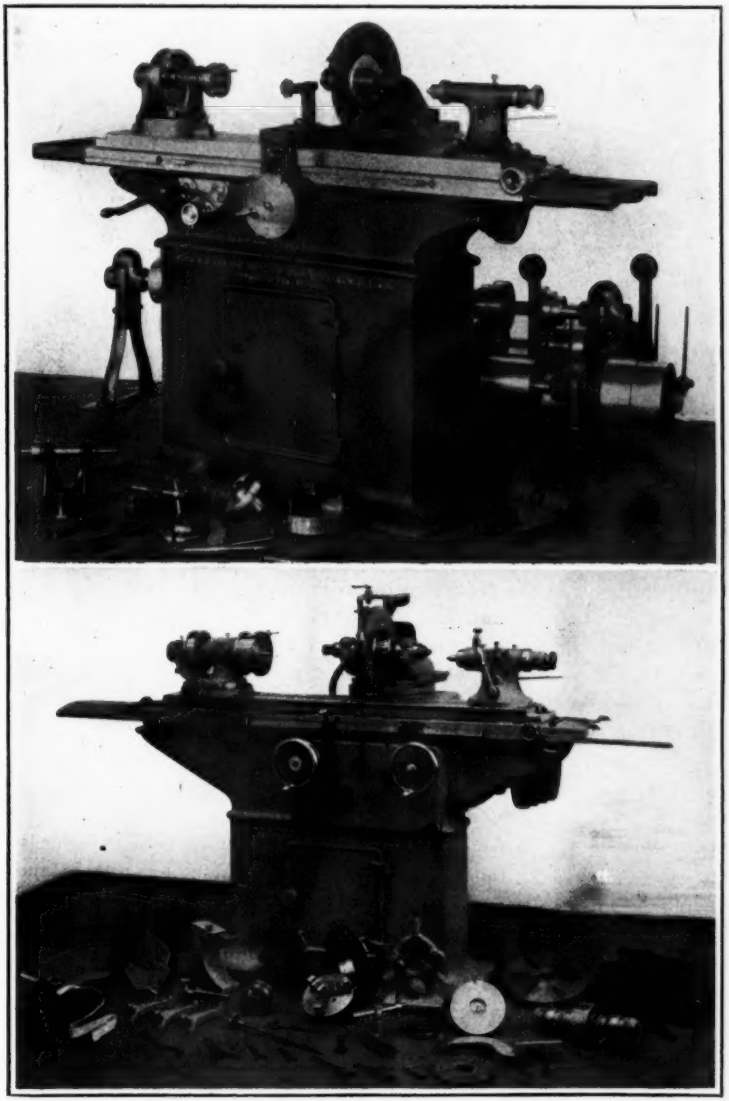
In this development, the greatest obstacle to be overcome has been to obtain finished work—that is, work free from chatter—and to obtain it in reasonable time. The earlier successful machines, which were all of a capacity approximating 12 inches by 48 inches, used grinding wheels of about ½-inch face, run at a surface speed of about 6,000 to 8,000 feet, work speeds of about 200 feet, and a traverse of about 1/16 of an inch or less per revolution of work. There are records of very much faster work speeds and slower traverse per revolution, but these were the first commercially successful speeds for general work. These wheels were at first made narrower at the cutting edge, sometimes as narrow at ⅛-inch, and for a long time this was the general practice.

The first attempts to increase the output, were by using the full width of a ½-inch-face wheel and greater traverse per revolution. This increase was met with chatter marks.

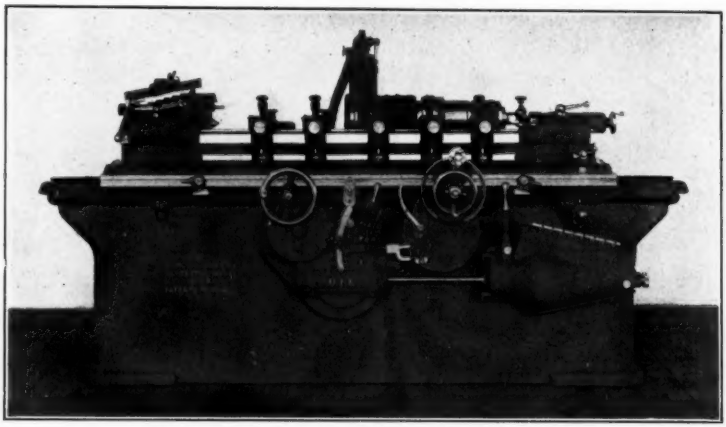
Various attempts to remedy this were made with different grades and grains of wheel, sometimes successful and sometimes not; then the grinding machines were made heavier. This was one of the most essential steps in the right direction, but not until the work speeds were reduced was really satisfactory progress made. With this knowledge came a gradual change in the general practice. Wheels were increased in face from ½ to even 1½ inches for smaller machines; traverse per revolution was increased in proportion. A further increase was made in the weight of the machines. Then the advantage of the back rest began to be appreciated, and from supplying one back rest to a machine, which was the earliest practice, the number of rests has increased until today it is usual to supply one for every 12-inches length of work, or even less.

At the same time the water supply was increased from a scanty stream just about enough to keep the wheel wet, to the full area of a ¾-inch or 1-inch pipe.

The net result of these changes has been to transform the grinder from a delicate machine suitable only for a little tool-room



BROWN & SHARPE NO. 2 GRINDING MACHINES OF 1876 AND 1906.
The older one is above, the new model below



BELT DRIVEN 10 BY 50 INCH GRINDING MACHINE.
Norton Grinding Co., Worcester, Mass.

work, such as grinding tools and hardened steel for various purposes, to a solid, powerful machine tool, almost capable of competing with the lathe in the reduction of work, and wholly distancing it in the matter of sizing and finishing work.

The accompanying illustrations also show the general improvement in design and appearance of the machines; and one striking feature which they bring out is the great increase in the number and variety of fixtures with which these machines are supplied.

The Brown & Sharpe No. 2 machine of 1876 was practically the first wet-grinding machine on the market. A comparison between it and their No. 2 machine of today shows many marked changes along these lines. The most significant are wider emery wheels, a decided increase in the water supply, a much more suitable and handy arrangement for controlling it, a great increase in the number of back rests and attachments, and in weight.

One feature which has been greatly developed on the Brown & Sharpe machines is the automatic feed. This is so designed that it automatically effects a movement of the emery-wheel base, equivalent to a work reduction of one-quarter of .001 inch or more, either at each reversal of the table, or at one end of the work only; and it can be arranged so that the wheel will dwell for a certain number of revolutions of the work at each reversal of the table.

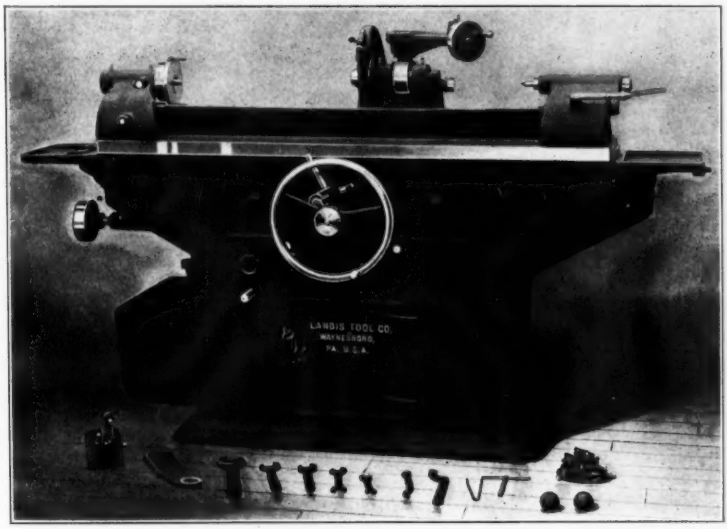
The first grinding machine built by Mr. Landis weighed about 3,000 pounds, while their present No. 1½, which compares with it in capacity, weighs about 4,800 pounds.

The Landis No. 3 machine, illustrated, of 1892, weighed about 3,800 pounds, and used a wheel 12 inches in diameter by ½-inch face. The present type No. 3 machine weighs 5,800 pounds and uses a wheel 1-inch to 1½-inches face.

The two Norton machines illustrated, their 10 inch by 50 inch belt-driven, and 18 inch by 168 inch motor-driven, are their latest type of machines, the latter being one of the largest machines on the market. One of the distinctive features of these machines is their handiness in the matter of speed control, both the work and traverse speed variation being obtained by the manipulation of levers.

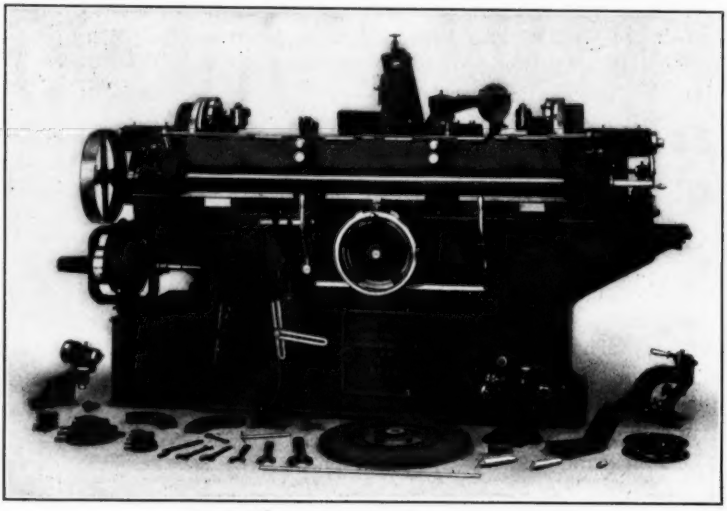
The Landis Tool Co. have also brought out some large machines, having regularly on the market a machine with a capacity of 30 inches by 150 inches, weighing 40,000 pounds and taking a wheel 30 inches in diameter by 3-inch face. They have also recently built a machine of 20-inch swing taking 200 inches between centers. This company have developed a crank-shaft grinding machine using a 24-inch diameter emery wheel and having heads with fixtures adapted to carry two, three, four, or six-throw cranks, and having an indexing device whereby for any of these throws the wrist pins may be quickly aligned with the work centers for grinding.

Co-incidentally with the development of machines, the face,



LANDIS TOOL COMPANY'S "PLAIN GRINDER NO. 3" OF 1892.

grade, and grain of grinding wheels used has undergone considerable change. Wheels are now wider, coarser, and softer than formerly, and are less frequently changed for a change of material, a variation in work speeds being often all that is necessary.

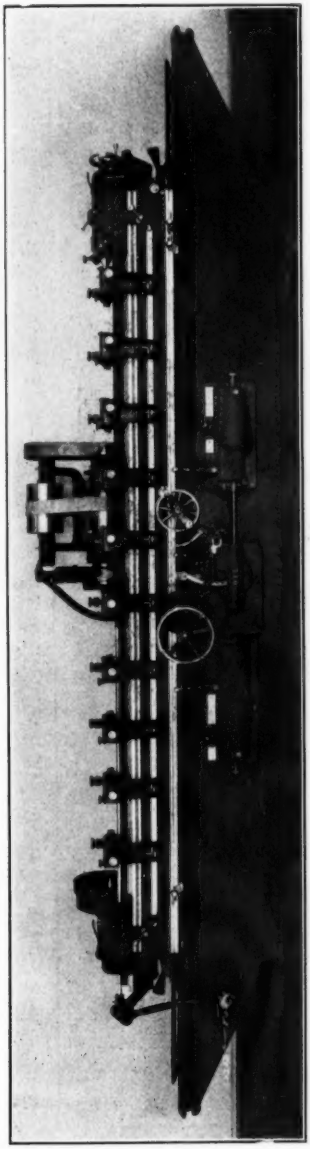


LANDIS CRANK SHAFT-GRINDING MACHINE.

The general practice of these three companies in regard to wheels and speeds is now much alike, except in work speeds; but in the latter point there is a great variation between that of Brown & Sharpe and the other two.

The following table shows in a comparative way these differences:—

Name of makers.	Grinding wheel surface speeds ft. per min.	Work surface speeds ft. per min.	Traverse per revolution of work unit—width of wheel face	
			Roughing	Finishing
Brown & Sharpe	6000—8000	75—100	$\frac{1}{4}$—$\frac{3}{8}$	$\frac{1}{16}$—$\frac{1}{8}$
Landis Tool Co.	5000—6000	10—40	$\frac{3}{8}$—$\frac{1}{2}$	$\frac{1}{8}$ or less according to finish
Norton Grinding Co.	5500--6000	6—40	1	less according to finish



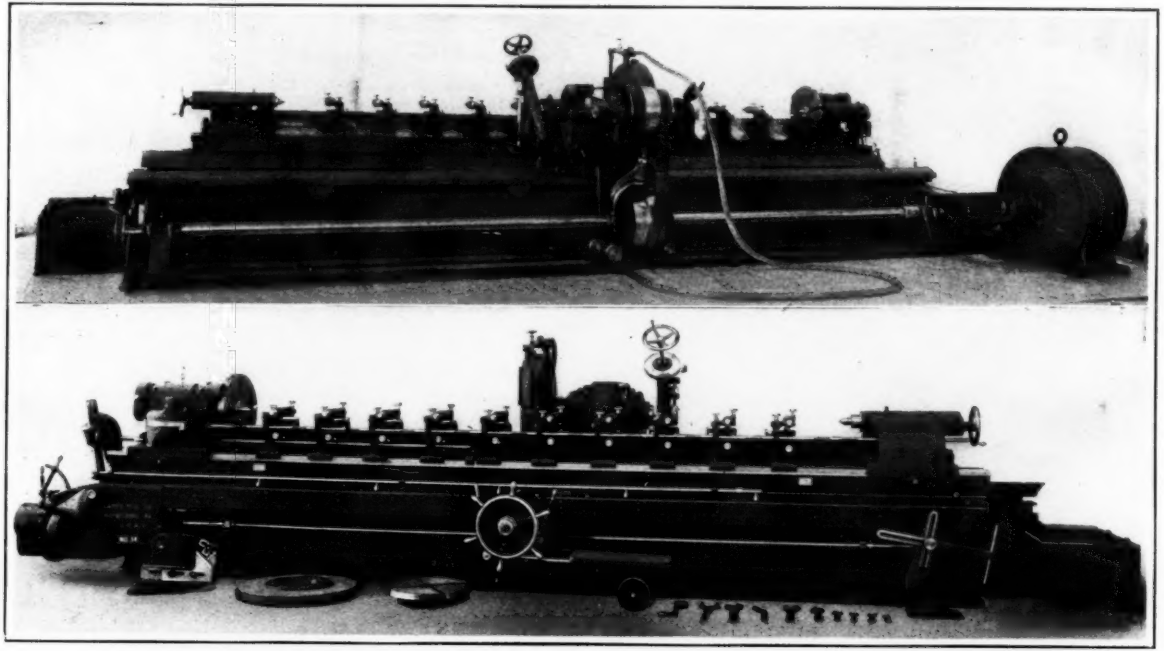
NORTON GRINDING COMPANY'S 18 BY 168-INCH MOTOR-DRIVEN GRINDING MACHINE.

For grinding wheels all recommend about the same grade and grain of wheel.

Brown & Sharpe use carborundum 70 grade K, corundum 46 grade 2½, and emery 36 grade 4, for soft steel, cast iron, and bronze, recommending a slightly finer wheel for hardened steel. Landis Tool Co. use for practically everything wheels varying from 24 to 60, and of a medium grade to about two grades softer. Norton Grinding Co. use mostly 24 combination wheel, grade L, occasionally grade M.

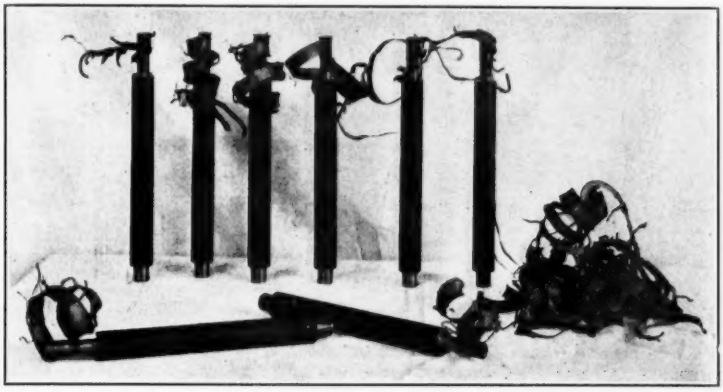
It will be seen that the Norton Grinding Co. and the Landis Tool Co. have gone very much further than the Brown & Sharpe Co. in the reduction of work speeds and increase of traverse per revolution. The two former also believe in a much wider-faced wheel for the same capacity of machine. For instance, the Brown & Sharpe No. 14 machine of 10 inches by 48 inches uses a 1½-inch-face wheel, while the Landis No. 23, 12 inches by 42 inches, uses a 2½-inch wheel, and the Norton 10 inch by 50 inch machine uses a 2-inch-face wheel.

How far this development will continue along these lines is problematical. It may be that the limit has about been reached. On the other hand, it is possible that a very wide wheel, say 6-inches face, with work supported by back rests very close together, would remove stock as much faster than a 3-inch wheel,



"SEMI-UNIVERSAL" LANDIS GRINDING MACHINE, 20 BY 174 INCHES. FRONT AND REAR VIEWS.

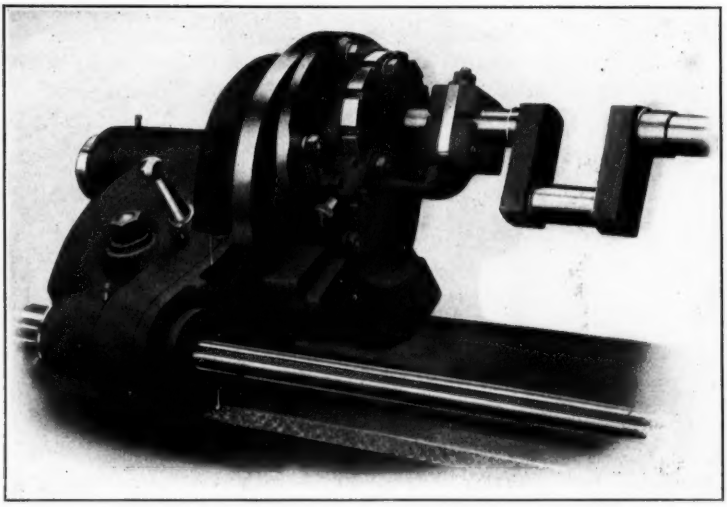
as the latter does than a 1½-inch. But granting that this would be the case, and that it could be done with freedom from chatter, the additional power required would probably cost more than the saving in time, for the large wheels require lots of power behind them.



SPINDLES WITH CHIPS FROM THE GRINDING MACHINE.

Formerly it was considered impossible to grind any thing but straight cylindrical, tapered, or flat surfaces, owing to the fact that it was thought necessary that the wheel or work have longitudinal traverse, one with respect to the other. Recently, however, much work has been done, when shape permits, by simply sinking straight in with the wheel, for its full width, without any traverse. As an example of this work are shown some spindles ground in the Landis Tool Company's works, where a short neck of comparatively small diameter was to be put on the end of a spindle. This neck was ground down from the rough, and reduced in diameter from 1 3/16 inch to 15/32-inch, using a 1½-inch-face wheel. In roughing out these ends, taking a heavy cut, the cuttings from the metal became fused together and curled up in chips much in the same manner as if a cut were taken with a wide lathe tool, and the photograph shows these ends with the chips still hanging to them. During this operation, stock was removed at the rate of 1¾ inches per minute.

In much the same manner it has been found practicable to finish pulleys, both single stepped and cone pulleys, and put on the crown, with a wheel of face as wide as the pulley. The surface of the wheel is first given a concave face by means of a diamond truing



FIXTURE FOR ALIGNING CRANK, FOR FINISHING BY GRINDING.

device working on a long radius, the arrangement being such that the actual radius may be made greater or less according as the face to be ground is wider or narrower.

The work is roughed out on the lathe, leaving a straight face, and all the crowning done with the emery wheel.

It has been found practical to finish cone pulleys having six steps from 10¼ inches to 4½ inches in diameter with 1½-inch faces in this way at the rate of ten per hour.

Another new form of work, ground, originating partly through the demands of the automobile industry, is a large radius on fillets such as on the wrists of crank-shafts. For this purpose a radial diamond tool has been brought out which will put a convex radius on each edge of the wheel, any radius being obtainable up to ¾ inches. In this case, owing to the varying length of the crank wrists, usually a slight traverse of the work or wheel, one with relation to the other, is required.

NOTE.—The author is indebted to C. H. Norton, the Browne & Sharpe Mfg. Co., and the Landis Tool Co., for much of the material of this article.

HIGH-LIFT TURBINE PUMPS. THEIR DESIGN AND EFFICIENCY.

By R. J. Durley.

It has long been known that the ordinary centrifugal pump is not an efficient machine when operated against high heads, and it is only within a comparatively recent date that its scope has been extended by the simple plan of arranging several pumps in series, each delivering to the next, a cumulative pressure thus being attained without excessive rotative speed, much in the same manner as an increase in electrical voltage is secured by connecting a number of battery cells in series. Another simple process seems to have taken a long time for its practical inception, the application of the principle of reversibility, rendering all the fund of experience in the improvement of the hydraulic turbine available for the machine in which work is put instead of being taken out, while the water flows up instead of down. Professor Durley gives a clear review of the work which has been done in this important department of engineering during the past few years, showing that it means an extension of the field of the hydraulic engineer, without encroaching upon the domain of the reciprocating pump.—THE EDITORS.

GOOD mechanical engineering requires the attainment of the desired end by the use of the simplest, most economical, most durable, and most reliable means. Progress in the solution of mechanical and electrical problems involves methods of simplification more frequently than of complication, and this tendency is well exemplified in the changes that have recently taken place in the design of machinery used for pumping against high heads. Until quite lately a reciprocating pump was a necessity for dealing economically with pressures exceeding about 60 feet of water, and the difficulties experienced in driving large pumps of this kind by electric motors seriously limited the use of electric driving for pumping purposes. Heavy and expensive gearing, with its accompanying noise, vibration, and liability to break down, was a necessity in most cases. The only kind of reciprocating pump available for direct driving by slow-speed motors was the so-called "Express" type, fitted with mechanically operated valves, and the use of these pumps was also open to the objections of complication and high cost of installation and maintenance, although they achieved remarkable results at high speeds and lifts as compared with the older geared forms.

The centrifugal pump, in which there is only one moving part, the runner or impeller, is, of course, the simplest form of pump from a mechanical point of view. Unfortunately the commercial use of such pumps has hitherto only been possible under certain conditions, and

for low heads, but a machine of the same simple mechanical construction and having only one moving part is now available for high heads, in the shape of the high-lift turbine pump.

The name high-lift centrifugal pump is, however, equally applicable, for such pumps are essentially centrifugal pumps in which a ring of guide blades surrounds the impeller. They are, therefore, practically reversed inward-flow (Francis) turbines, but of course differ from such turbines in the shape and curvature of their wheel vanes and guide blades.

It is well known that the ordinary centrifugal pump has a low efficiency when working against high heads. This is due to the fact that with high speeds in pumps of this kind the frictional and eddy losses bear a very high proportion to the amount of useful work actually expended in pumping the water. A typical centrifugal pump of ordinary design, showing a maximum efficiency of say 70 per cent at 20-feet lift, will show only about 20 per cent at 80 feet. Efforts to utilize such centrifugal pumps for higher lifts by running two or more in series have not achieved commercial success.

The water streaming from the rim of the impeller of a centrifugal pump possesses kinetic energy, derived directly from the work expended in rotating the pump shaft. If the vanes of the impeller were radial in an ideal frictionless centrifugal pump, and if the whole of the kinetic energy of the water at the rim of the impeller could be transformed into pressure energy, then the pressure (measured in feet of water) against which such a pump could just deliver, would be calculated by the expression $v^2 \div 32.2$, where v is the linear velocity of the rim of the impeller in feet per second.

If we take the case of water delivered from an ordinary centrifugal pump with a velocity of 10 feet per second in the discharge pipe, and under 50-feet head, the total energy possessed by each pound of water delivered is 51.55 foot-pounds, of which 1.55 foot-pounds is kinetic energy and 50 foot-pounds is pressure energy. An ideally perfect pump would, of course, attain this result by the expenditure of only 51.55 foot-pounds of work per pound of water pumped, and the impeller would have a peripheral velocity of about 41 feet per second An actual pump, however, working under these conditions, and having an efficiency of perhaps 50 per cent would evidently require the expenditure of twice as much work per pound of water pumped, and, further, the impeller would have to be driven at a considerably higher speed, depending on the design of the pump, but probably about 60 feet per second. To judge of the performance of a centrifugal pump, under

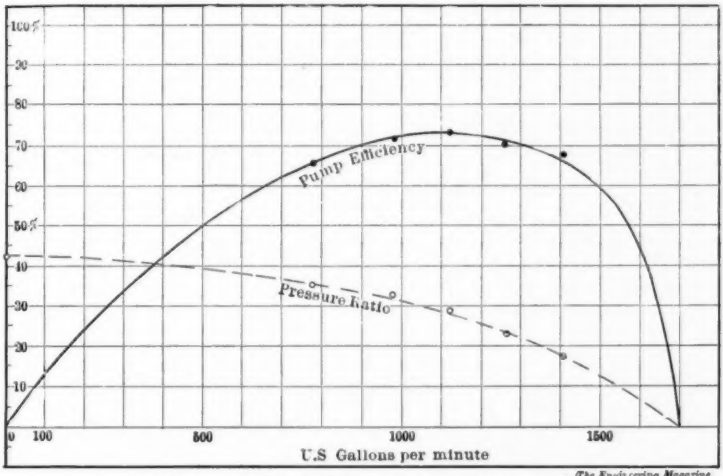


FIG. 1. TESTS OF 8-INCH CENTRIFUGAL PUMP.

At constant speed of 2,000 revolutions, 45 ft. lift; diameter of impeller 8.3 inches; De Laval Co.

any given conditions, it is thus necessary to know two quantities; (a) the efficiency, or ratio of the useful work done to the work expended in driving the pump; and (b) the "manometric coefficient," or pressure coefficient, which is the ratio of the actual pressure in the pump discharge to the pressure which would be attained in an ideally perfect pump with the same peripheral velocity of impeller. Curves of these two quantities, plotted with regard to the amount of water discharged will give all necessary information as to the performance of a pump at a given speed throughout its whole range, from the point at which the discharge is zero and the pressure large, to the point at which the pressure is zero and the discharge a maximum. The forms of these curves are affected very considerably by the shape of the vanes of the impeller, and can be varied by a skilful designer to suit the special conditions under which the pump is to work. Figure 1 shows the efficiency and pressure curves as drawn for an 8-inch low-lift centrifugal pump tested by Messrs. Denton and Kent. The pump was designed for a delivery of 1,200 U. S. gallons per minute against 45 feet head when running at 2,000 revolutions per minute, and it will be seen that while the maximum efficiency of the pump occurs at very nearly the designed rate of discharge, it falls off very rapidly when delivering larger quantities of water. The curves of Figure 1 correspond to the forms usually shown by pumps in which the vanes are

curved backwards at the tip, and such impellers may be used in cases where a pump has to work with fair efficiency at constant speed while the head is varied over a considerable range. It is possible by modifying the shape of the vanes and making them more nearly radial, to obtain a pressure-coefficient curve which is approximately horizontal for a considerable variation of the amount of water pumped, indicating that with such an impeller when the demand for water is changed the pressure will remain nearly constant while the pump runs at constant speed. Such a design is evidently suitable for a pump supplying a boiler-feed system, a service which is now well within the capacity of a high-lift centrifugal pump. By still further changes in the design of the vanes, we are even able to obtain a pump in which the head increases as the delivery is increased. In an electrically driven pump, where there is danger of overloading and burning out the motor by opening the discharge valve and increasing the amount of water delivered by the pump, backward-curved vanes should be used, and in most cases the pump should be so designed as to cause the pressure-coefficient curve to drop sharply at a point just beyond the intended maximum delivery.

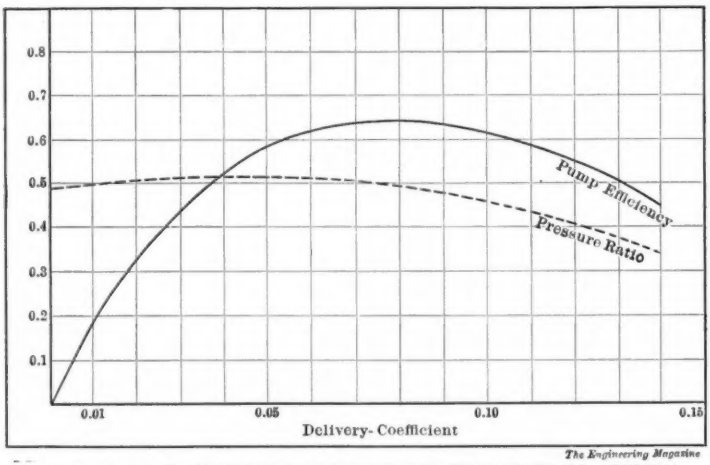


FIG. 2. RATEAU MULTIPLE-STAGE PUMP FOR HUANCHACA CO., BOLIVIA. 1,450 revolutions, 590 ft. head, 925 imperial gallons per minute.

Such curves as those just given may be called the characteristic curves of the pump, although they apply only to the particular pump and speed for which they are drawn. In has been pointed out by M. Rateau that instead of measuring quantity of water along the base

line of such curves, a quantity called by him the "delivery-coefficient" *"coefficient de débit"* or *"pouvoir débitant"* may be used with advantage. This delivery-coefficient is numerically equal to the amount of water discharged, divided by the peripheral velocity of the impeller, and by the square of the radius of the impeller. A given characteristic curve plotted in this way then becomes applicable to all sizes of pumps of the same design, providing that for each size the correct speed is used. This result follows from the fact that the quantity delivered by an ideal centrifugal pump would vary as the peripheral velocity of the impeller, and also as the square of the linear dimensions of the pump. Figure 2 gives such a characteristic curve for a four-stage high-lift turbine pump; the general similarity of the curves to those of Figure 1 will be evident.

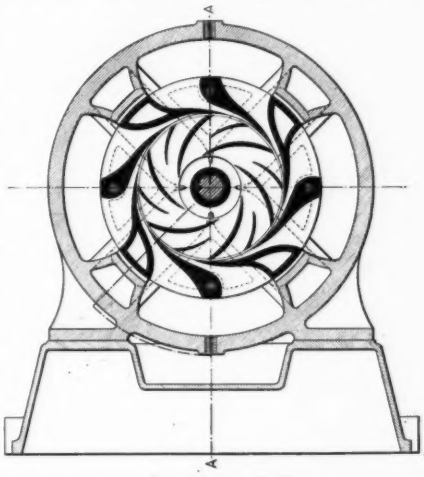


FIG. 3. CROSS SECTION THROUGH HIGH-LIFT TURBINE PUMP, SHOWING ARRANGEMENT OF IMPELLER, DIFFUSION RING, AND GUIDE BLADES.
Buffalo Steam Pump Co., Buffalo, N. Y. See also longitudinal section page 511.

As has already been stated, the improvement which differentiates the high-lift centrifugal or turbine pump from the ordinary low-lift centrifugal pump, consists in the addition, outside of the impeller, of a "diffusion-ring" containing stationary guide blades (Figure 3). By means of these guide blades the water leaving the impeller is smoothly conveyed to the annular discharge chamber surrounding the guide ring, and its velocity head is thus more effectually converted into pressure head. In other words, the rapidly moving water leaving the impeller is led into the pump-discharge space with less loss of energy from shock or eddies than would otherwise be possible. The high peripheral velocities of impeller necessary for high heads can then be employed without a corresponding diminution of efficiency. The practical result obtained by this method of construction is that pumps having a single impeller can deal with heads exceeding 100 feet with good economy; the efficiency possible depends on the design of

the pump, and especially on the relation between the diameter of impeller, the required number of revolutions, and the amount of water to be pumped. By placing turbine pumps in series, so that the first impeller discharges into a space connected to the suction of the second wheel, and so on, a multiple-stage pump is obtained, and it is evidently possible to pump against correspondingly greater heads; under these conditions a pump efficiency of over 70 per cent is frequently attained. The greatest head dealt with commercially up to the present time appears to be about 1,500 feet, but for such a lift the usual practice would be to use two or more multiple-stage pumps in series. The usual head for a single multiple-stage pump is from 300 to 600 feet.

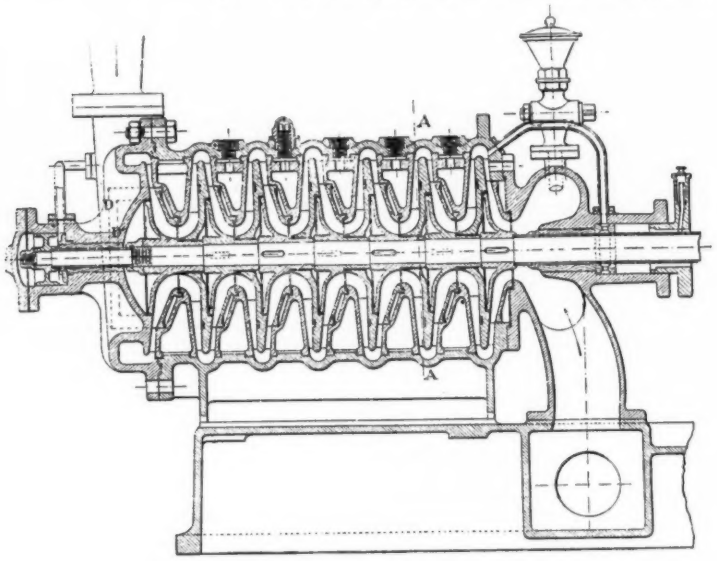


FIG. 4. LONGITUDINAL SECTION THROUGH SEVEN-STAGE RATEAU HIGH-LIFT CENTRIFUGAL PUMP.

MM. Sautter-Harlé, Paris.

It must not be supposed, however, that such results as those just stated have been attained without much trouble, and without overcoming many practical difficulties. One of the first of these difficulties to make itself felt was that arising from end thrust on the pump shaft. In a single-stage turbine pump, as in an ordinary centrifugal pump, the water at entrance to the impeller is flowing parallel to the axis of the shaft, and in being deflected so as to move in a radial direction it exerts a considerable thrust along the shaft. The simplest

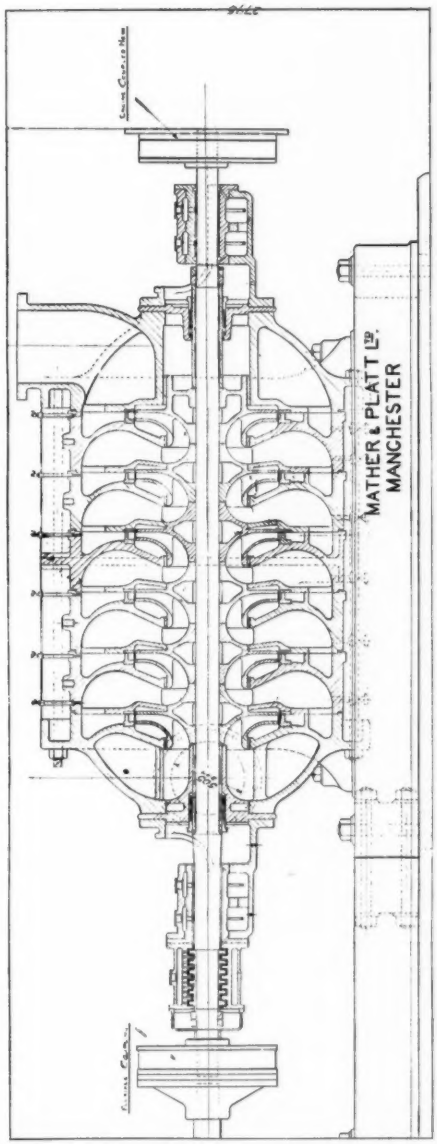


FIG. 5. LONGITUDINAL SECTION THROUGH SIX-STAGE HIGH-LIFT PUMP, SHOWING BALANCING DISC.
Designed for 4,500 imperial gallons per minute against 300 ft. head at 335 revolutions. Mather & Platt., Ltd., Manchester.

method of avoiding this is to use an impeller taking water from both sides, as in the case of the ordinary double-suction pump. But when a number of impellers are placed in series on the same shaft, as in the case of the seven-stage pump of Figure 4, this arrangement becomes somewhat difficult to carry out, and in the pump illustrated the impellers take water on one side only. The end thrust is then taken care of by suitably proportioning the areas of the two sides of each impeller, and by the use of a rotating balance piston, one side of which is exposed to the pressure in the discharge pipe. It will be noticed that in this pump the impellers have a larger diameter on the inlet side than on the side nearest to the pump discharge; these areas are chosen so that the difference of the total pressures on the two sides of each impeller

balances its own end thrust as nearly as possible. In the design of Figure 5 single impellers are also used, but in this case pressure is admitted to the face of a rotating disc of proportionately larger diameter, and collars on the shaft are provided to take up any thrust that may occur when the pump is running at variable load. With this arrangement there is of course a certain amount of leakage from the discharge into the suction of the first impeller, but the amount of water lost in this way is very small, and the adjustment of a valve in the balancing pipe renders it possible to vary the pressure on the balancing disc so as to allow for any change in the amount of end thrust to be balanced, resulting from an alteration in the amount of water delivered or in the head overcome.

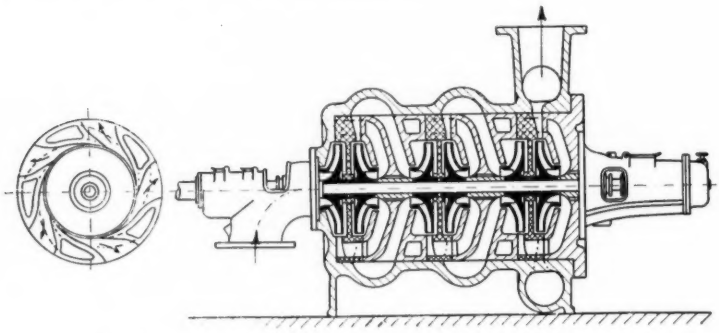


FIG. 6. LONGITUDINAL SECTION THROUGH SIX-STAGE PUMP.
Gebrüder Sulzer, Winterthur.

One of the first multiple-stage pumps adopted an arrangement in which the impellers were placed in pairs back to back (Figure 6), and this system is still followed by several builders. In the Buffalo pump Figure 7 we have a somewhat similar design, in which the spaces between the outer faces of the impellers and the adjoining casings are used as pressure chambers, each being filled with water at the delivery pressure of its own impeller. Packing rings are fitted, so as to prevent leakage from the delivery to the suction side, and the areas of the two pressure chambers of each impeller are arranged so as to make the total difference in axial pressure approximately equal to the thrust due to the difference of inlet opening in the two impellers of the pair. In this way each pair of impellers is balanced separately. Evidently in a pump of this kind an even number of stages must be employed.

The pump of Figure 8 also utilizes the opposing thrust of the various impellers so as to produce a balanced shaft, but in this case

single impellers are used, an equal number facing each way. The arrangement is an ingenious one, and does away with the necessity of making ports in the division plates between the stages (as is done in the pumps of Figures 6 and 7), in order to provide openings through which the water can pass from the guide blades of one stage to the suction of the next. In Figure 8 these connecting passages are all formed in the outer casing of the pump, and while not so short and abrupt as in the pumps of Figures 6 and 7, afford a considerable area of wetted surface exposed to the friction of the water. It will be seen that the pump of Figure 8 is also provided with pressure chambers, and has no thrust bearing or rotating piston.

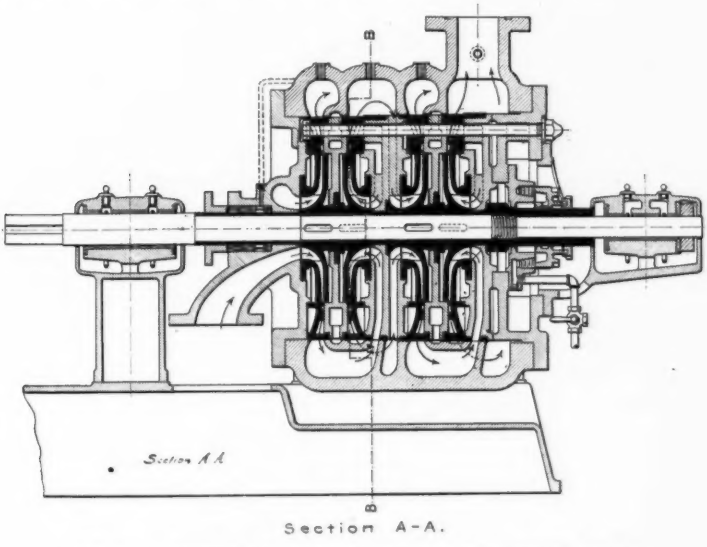


FIG. 7. LONGITUDINAL SECTION THROUGH FOUR-STAGE PUMP.
Buffalo Steam Pump Co., Buffalo, N. Y. Compare with cross section on page 507.

Another method which can be employed to balance a single-suction impeller involves the use of radial vanes formed on the outside surfaces of the impeller, and therefore rotating the water in the pressure chambers. By proportioning correctly the length and clearance of these vanes, the pressures existing in the various pressure chambers while the pump is running can be brought to the amounts required for balance. These so-called "triple vanes" no doubt increase slightly the power required for driving the impeller, but it is questionable

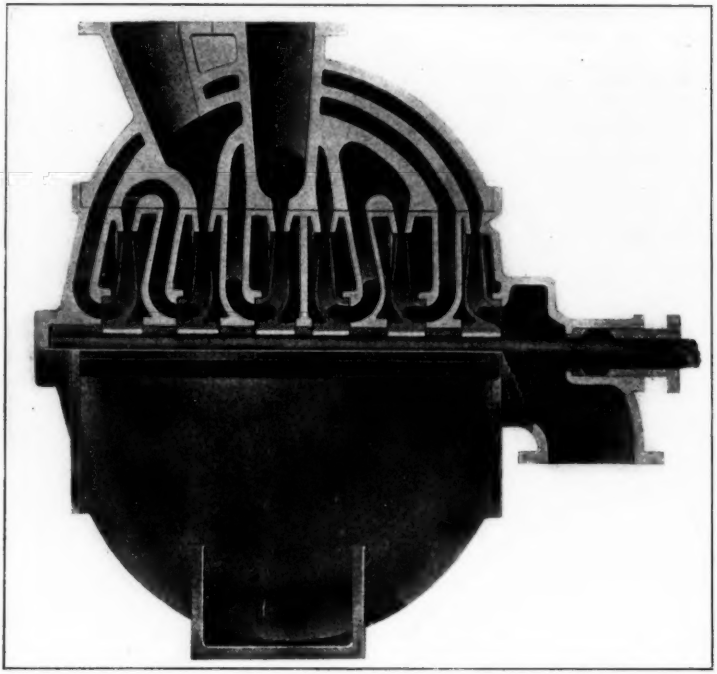


FIG. 8. LONGITUDINAL SECTION THROUGH SIX-STAGE PUMP.
Lawrence Machine Co., Lawrence, Mass.

whether the power wasted in the thrust bearing of an imperfectly balanced pump would not be greater than any loss due to the triple vanes.

The system of making holes in the sides of the impeller, adopted also in certain water turbines of the Francis type, has been used by some builders of high-lift turbine pumps. The object of such holes is, of course, to obtain the required pressure on the outer surfaces of the impeller by admitting water from the inside passages to the pressure chambers.

The construction of the main bearings and stuffing boxes in a high-lift turbine pump has to be carefully considered. It is good practice to arrange the design so that the bearings and stuffing boxes are quite separate; in this way the weight of the shaft and its impellers is carried by easily accessible bearings, no grit from the water can get to the journals, and the stuffing boxes are able to perform their own

duty without taking any of the load. The tightness of the stuffing box on the suction side of the pump is specially important, and this box is generally provided with a water supply, so that any leakage into the pump will be of water and not air. Figure 7 shows an arrangement of double stuffing box for the suction side fitted with such a water-logging attachment. Those who have heard a high-lift pump when running partly full of air will realize the importance of this, and a comparatively small air leak on the suction side will suffice to prevent the pump from working at all. The pump may be constructed so that water leaking from the last pressure chamber is used to cool the bearings (Figure 9).

The total length of shafting in a motor-driven multiple-stage pump is considerable. It is generally advisable to use a flexible coupling between the pump and motor, so as to allow for any small change of alignment as the pump or motor bearings wear. In small pumps with shorter shafts, solid couplings can be used.

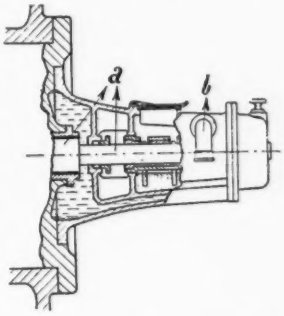


FIG. 9. SECTION SHOWING CONSTRUCTION OF PUMP BEARING.
Gebrüder Sulzer, Winterthur.

Other points requiring attention in design are, the protection of the exposed portions of the shaft from corrosion, for which purpose brass casings are employed; the prevention of leakage from one stage to the next, by fitting brass packing rings, as in the pump of Figure 7; and the arrangement of the impellers and division plates so as to admit of easy assembly and removal without interfering with permanent pipe joints or connections. The form of the guide passages in the diffusion ring, and the shape of the ports or passages leading from one stage to the suction of the next, have considerable effect on the efficiency of the pump, and on the arrangement of these details much ingenuity has been expended. Provision should be made for measuring the pressure at each stage, so that any serious leakage arising through mechanical injury to one of the impellers or guide rings may be detected and localized. From motives of economy in construction, turbine pumps are usually made up of a series of similar sections, so that successive stages are exactly alike, and a pump to work under any desired head can be made up by assembling a proper number of these units.

The results attained by the modern high-lift centrifugal pump may be stated generally as follows; an efficiency in most cases of from

70 per cent to 75 per cent can be obtained, and under suitable conditions, when the relation between head and discharge is most favorable, this may even reach 80 per cent on trial. These efficiencies are from 5 to 20 per cent in excess of those obtained from pumps without diffusion rings. The pumps can be so proportioned as to give a fairly constant efficiency over a considerable range of discharge. When running light, and discharging no water, the power absorbed is generally from 25 per cent to 40 per cent (see Figure 10) of that required at the rated output of the pump, and is of course wasted in churning the water contained in the pump.

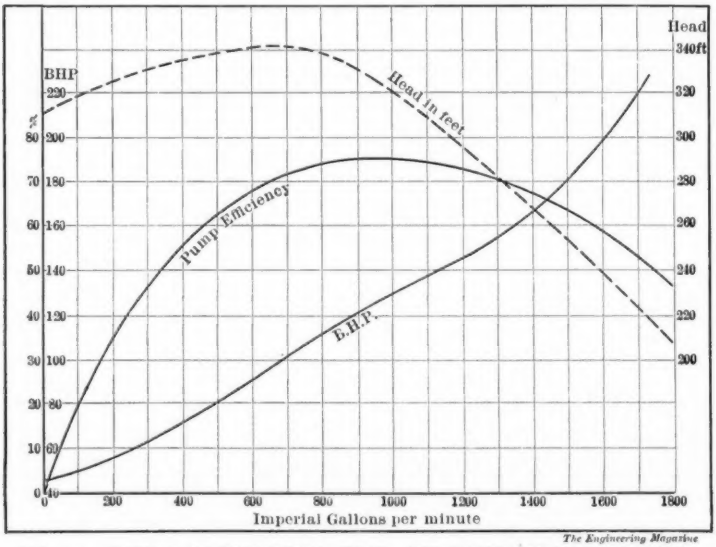
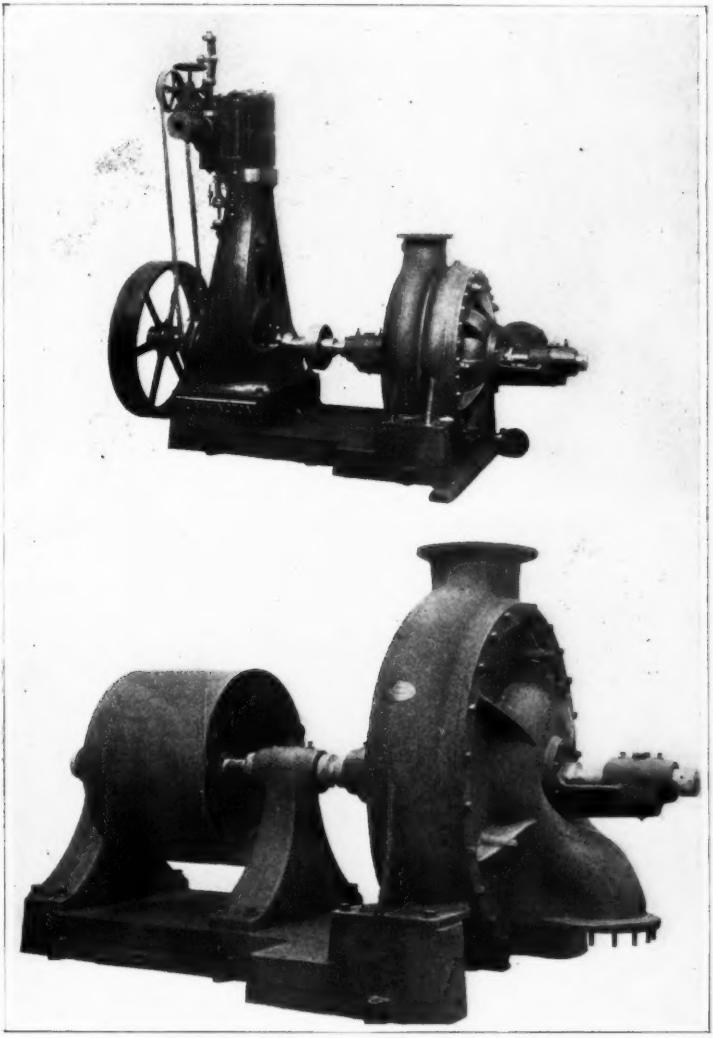


FIG. 10. CURVES OF EFFICIENCY, HEAD, AND BRAKE HORSE POWER FOR FOUR-STAGE PUMP, FOR DE BEERS CONSOLIDATED MINES, KIMBERLEY.
735 revolutions; 320 ft. head; 1,000 imperial gallons per minute.
Mather & Platt, Ltd., Manchester, England.

In good practice the head to be overcome by each stage is from 100 to 200 feet, the lower limit being generally taken where possible. It is found that when the head per stage exceeds 200 feet it is difficult to get good efficiency, because the velocity of the water is so high, and, further, the durability of the pump is diminished, since the impellers and guide blades are liable to injury from a pitting action similar to that observed in the blades of screw propellers. The maximum speed of impeller permissible is also limited by the occurrence of a phenomenon analogous to that of "cavitation" in propellers, and if the impeller



FIGS. 11 AND 12. WORTHINGTON PUMPS—10-INCH ENGINE-DRIVEN AND 16-INCH BELT-DRIVEN.

The latter is single-stage, built for the Colorado Fuel & Iron Co.

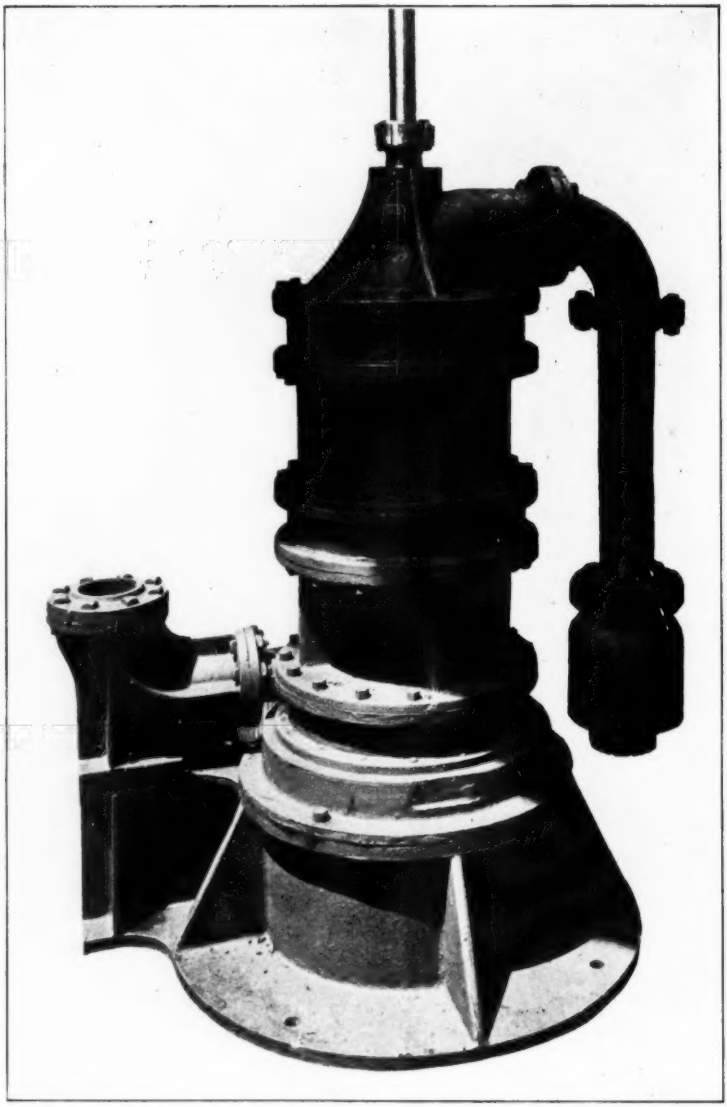


FIG. 13. THREE-STAGE BROOKS CENTRIFUGAL PUMP, VERTICAL TYPE, FOR MINE SERVICE.

For 350 ft. total head. Placed at the bottom of mine 190 ft. deep, with direct-connected motor 144 ft. above. Raises water to surface and pumps it through 19,000 ft. of piping. Suction at top; pump can be totally submerged. Dayton Hydraulic Machinery Co., Dayton, Ohio.

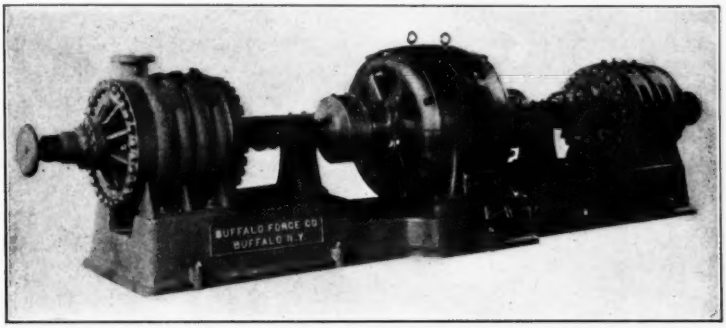


FIG. 14. BUFFALO EIGHT-STAGE 300-GALLON PUMP FOR NORTH-STAR MINES, GRASS VALLEY, CAL.

For 1,400 ft. head; 1,800 revolutions, 250-horse-power motor.

is driven too fast it becomes impossible for the water to flow into the pump suction with sufficient rapidity. The greatest number of stages at present employed is eight, but there seems to be no reason why a greater number should not be used.

It is probable that further progress will soon enable efficiencies corresponding to those of the best water turbines to be obtained, but such results will not be reached without the most careful design and workmanship. The smoothness of the surfaces of the water passages has, of course, an important effect on the efficiency of high-lift turbine pumps. It is unfortunate that these passages are usually of such

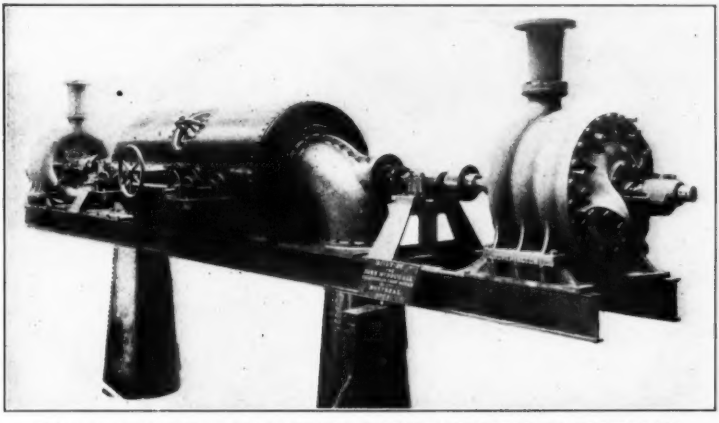


FIG. 15. TWO THREE-STAGE PUMPS, DIRECT-CONNECTED TO HORIZONTAL TWIN MCCORMICK TURBINE.

Can be operated either singly or in multiple; 750 imperial gallons per minute. Built by John McDougall Co., Montreal.

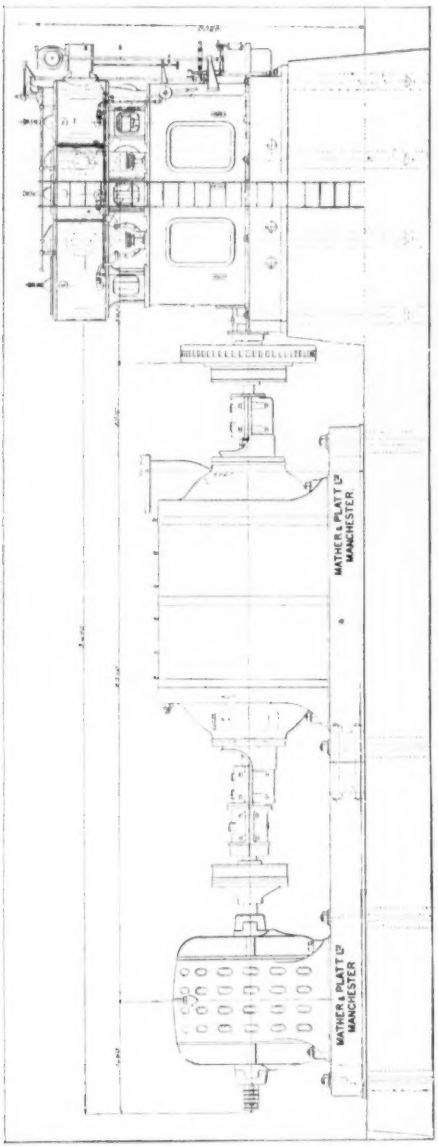


FIG. 16. GENERAL ARRANGEMENT OF 500-HORSE-POWER PUMP, MOTOR AND GAS ENGINE FOR CITY WATER SUPPLY.
4,500 imperial gallons a minute, 300 ft. head, 335 revolutions; three-phase, 63-cycle, 2,200-volt induction motor, rated at 537 brake horse power. Belliss & Morcom triple-expansion high-speed engine, direct-connected; forced lubrication.

shapes that they can only be finished by hand, and unless of brass, their surfaces are liable to be roughened by corrosion. Tests of turbine pumps after some years' working, however, have shown that when properly constructed there is little or no falling off of efficiency on account of wear and corrosion. Trials of the Sulzer pumps installed at the Horcajo mines in Spain, after one year's running and five years' running respectively, showed the same efficiency, 76 per cent; the head, however, had been raised in the interval from 1,275 feet to 1,575 feet, and the power required increased from 420 to 500 horse power. During this period of service, the time during which these pumps were not running averaged about 16 hours per month. It is worthy of remark that high-lift

turbine pumps can maintain their original efficiency much better than is usual with large piston pumps. The latter are very seldom kept in such perfect condition (as regards tightness of valves and plungers) as to enable their trial results to be duplicated at any time.

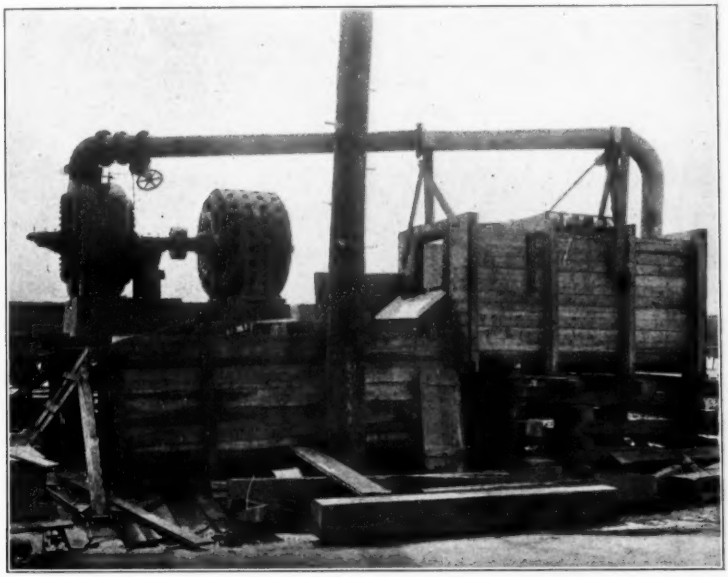


FIG. 17. TWO-STAGE PUMP ARRANGED FOR TEST.

Capacity 6,500,000 U. S. gallons per 24 hours, 710 revolutions, 260 ft. head.
Buffalo Steam Pump Co.

When we consider the expense of installation and maintenance of a turbine pump as compared with a reciprocating pump for the same duty, the contrast is very marked. The 500-horse-power pump and motor of Figures 5 and 16, for example, occupies a floor space (exclusive of the steam engine used as a stand-by in case of failure of the electric supply) only 31 feet 6 inches by 8 feet 6 inches, its capacity is 6,500,000 imperial gallons per 24 hours, or 4,500 gallons per minute, against a head of 300 feet; its weight with bed plate and engine is about 160,000 pounds, and it replaces a three-throw reciprocating pump driven by gearing from a 300-horse-power motor, occupying a floor space of 50 feet by 25 feet, and of nearly twice the weight, although capable of pumping only 4,500,000 gallons per 24 hours. The expense for valve renewals alone for a reciprocating pump of this size would be about $500 per year, and the cost of

lubricating oil would probably amount to at least the same sum per annum. The annual cost of maintenance of geared reciprocating pumps is often from 15 to 20 per cent of their first cost. The expense for valves is, of course, non-existent for a turbine pump, and the lubricating oil consumed by a turbine pump should be no more than that required by the electric motor driving it. The foundations for the turbine pump are much smaller and cheaper than those required for the reciprocating pump, and there is no annoyance from the noise and vibration caused by the gearing. Against these advantages we have to set off the smaller over-all efficiency, which in the above case is about 68 per cent at rated load, as compared with say 75 per cent for the reciprocating pump and motor. This means that a turbine pump of the size mentioned above will involve an additional cost for power of from $1,200 to $1,800 per annum, which is more than compensated for by the saving in interest on first cost, depreciation, repairs and maintenance, and in the cost of attendance.

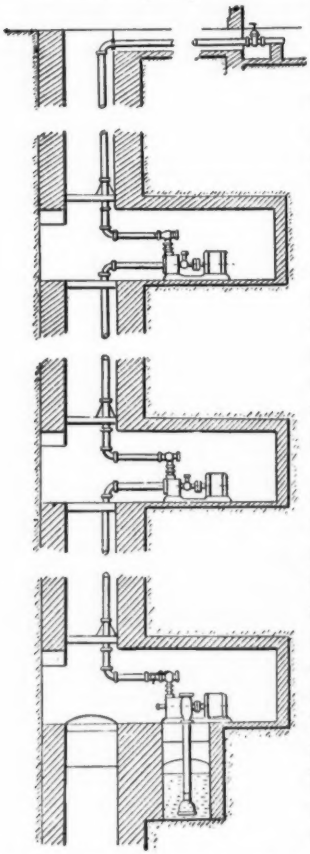


FIG. 18. ARRANGEMENT OF THREE MOTOR-DRIVEN FOUR-STAGE PUMPS, IN SERIES, AT HORCAJO, SPAIN.

Delivering 1,000 imperial gallons per minute against a total head of 1,500 ft. Gebrüder Sulzer, Wintherthur, Switzerland.

High-lift turbine pumps of the largest size are now being employed for water supply to cities and towns, and several of these pumps have already been illustrated (Figures 5, 7, 8, 16). They should be designed so as to give good results at constant head and through a considerable range of variation of discharge. The pump supplied by Sulzer Bros. to the city of Geneva in 1897 was the first application to this service. Figure 16 shows the general arrangement of the six-stage pump of Figure 5, which is used for city water-supply, and in which a high-speed engine is applied as a stand-by, so that the pump can be driven either by the motor or engine.

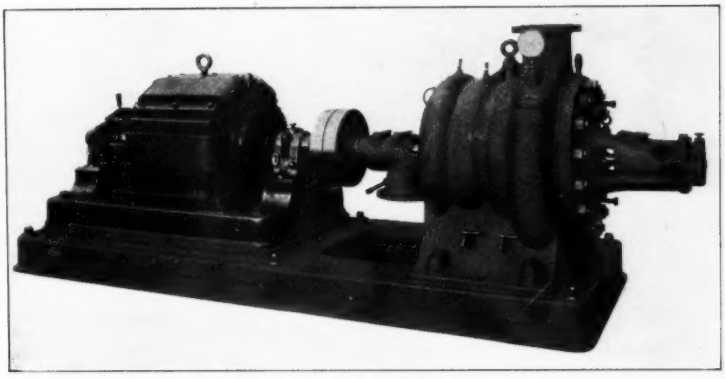


FIG. 19. FOUR-STAGE SULZER PUMP FOR MINE SERVICE.

890 U. S. gallons per minute against 655 ft. head; 1,330 revolutions, 215 brake horse-power.

High-lift centrifugal or turbine pumps have also found extensive use in mines. They are employed not only as permanently installed drainage pumps (Figure 18), placed conveniently in chambers excavated near the bottom of the shaft, but also as sinking pumps,

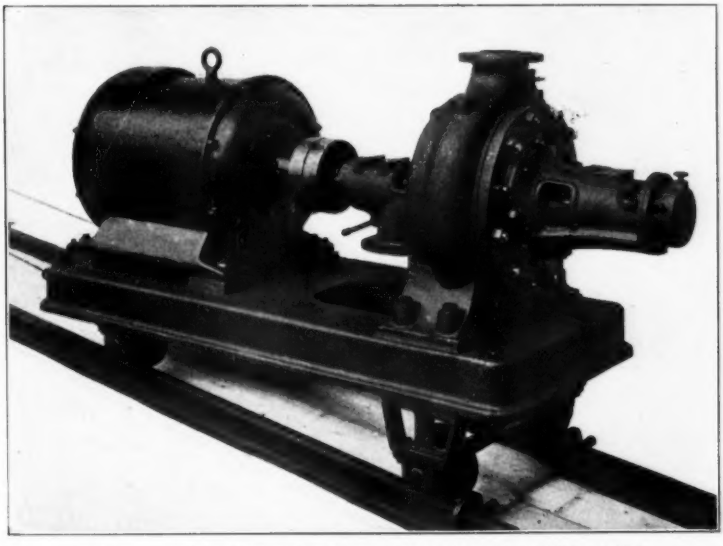


FIG. 20. TWO-STAGE SULZER PUMP FOR WORK IN A MINE DRIFT.

540 U. S. gallons per minute, 1,440 revolutions, 46 brake horse-power.

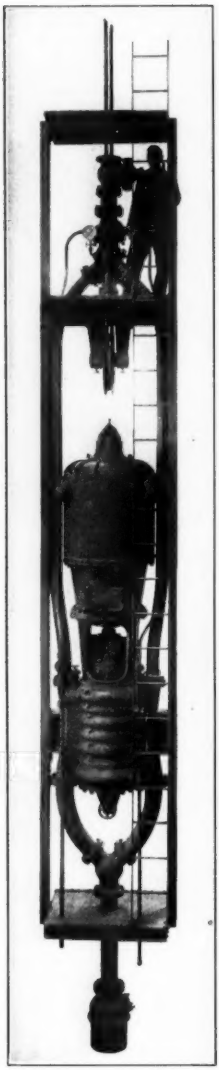


FIG. 21. SIX-STAGE SULZER SINKING PUMP.

540 U. S. gallons per minute against 785 ft. head; 1,458 revolutions, 150 brake horse power.

which can be suspended in the shaft, and even when of considerable power will still leave room for the passage of the cages or tubs of the hoisting apparatus. The sinking pump of Figure 21 is interesting on account of the size and high head, and the method of suspension in the shaft is clearly shown. Special care is necessary in the balancing of these vertical pumps, and for this particular service it is necessary to bear in mind the liability to damage from blasting operations, and the possibility that the pump may have to continue running when lifted clear of the water. The pump of Figure 20 is also a mining pump, and is intended to work in an inclined heading or drift; it can be moved forward as the work proceeds, and current is conveyed to it by flexible leads. The convenience and economy of this arrangement as compared with a pump driven by steam or compressed air is evident.

High-lift centrifugal pumps are finding a wide field of application for purposes of fire protection, both in factories and in cities. A fire-protection system now being installed in Toronto comprises two two-stage pumps of the Worthington pattern, each being directly connected to a steam turbine of 1,000-horse power. This arrangement was adopted because accommodation was available in an existing steam pumping station. The working pressure when the pumps are run as two-stage pumps in multiple is 300 pounds per square inch (700-feet head), but when required they can also be worked as single-stage pumps, giving a pressure of 150 pounds in the mains. This unusually high head for each stage was adopted for the sake of simplicity, and because in the case of a pump which works only occasionally high efficiency is not of paramount importance. The two pumps can deliver 2,900 imperial gallons per minute, and special provision is made for speed control of the turbines.

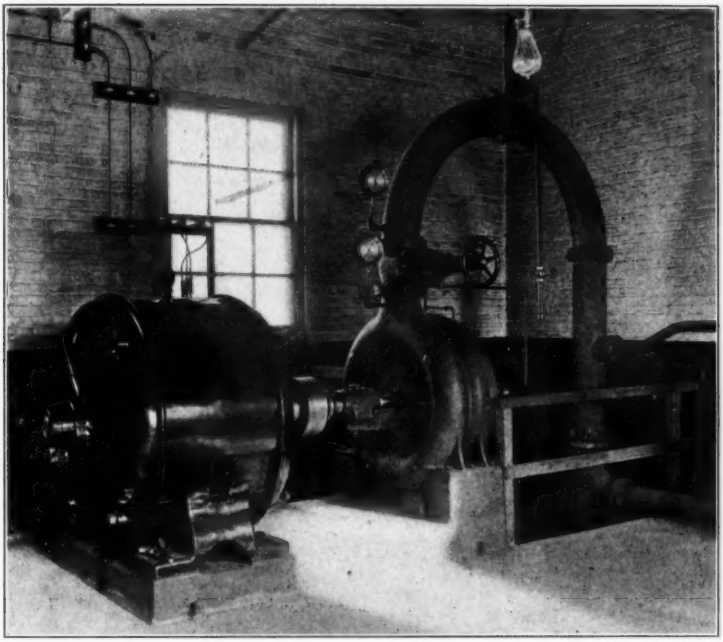


FIG 22. WORTHINGTON FIRE PUMP, INSTALLED IN THE CANADA SUGAR REFINERY, MONTREAL.

1,500 imperial gallons per minute at 150 lb. pressure. Two-stage. Built by John McDougal Co., Montreal.

In Europe high-lift centrifugal pumps driven by electric motors have been used as portable fire engines with considerable success.

For elevator service a motor-driven high-lift centrifugal pump will give good results if arranged with an electrically or mechanically controlled device, so as to vary the discharge automatically in conformity with the needs of the elevator. Such a pump is, of course, incapable of giving a pressure greatly exceeding the normal amount, so that no safety valves are required, and the closing of the main discharge valve cannot cause damage. An elevator pump should be designed so as to give a nearly constant head at all rates of discharge, and the same remark applies to the high-lift turbine pump when used for boiler-feed purposes. It is even possible to use such a pump, of course in conjunction with a dry vacuum pump, for taking water from a surface condenser and delivering direct into the feed pipe of a boiler system. The high vacuum under which the suction side of such a pump is working is not conducive to the most favorable results, how-

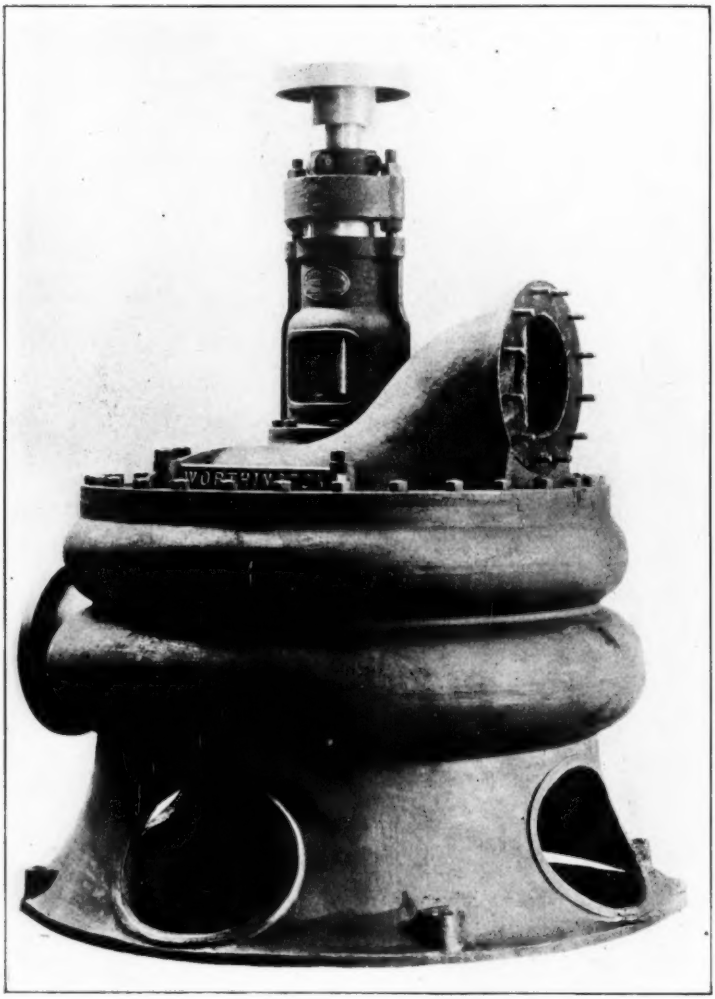


FIG. 23. TWO-STAGE VERTICAL TURBINE PUMP.

Capacity, 10,000,000 U. S. gallons against 100-lb. pressure. Henry R. Worthington, Inc., N. Y

ever, even although the water is run by gravity into the pump suction, and great care has to be taken to avoid leakage on the suction side.

A number of successful pumping installations have been carried out in which a high-lift pump has been driven directly by a water turbine. Such a turbo-pump, as built for mine service in Central America, consists of a four-stage Rateau pump having impellers 9½ inches in diameter, and driven at 2,200 revolutions per minute by a reaction turbine placed within the same casing. The 120-horse-power turbine, taking its water under a head of 520 feet, has a single wheel 11¾ inches in diameter, and delivers the water it has used into the discharge pipe of the pump; the pump works under a head of 390 feet and delivers 400 imperial gallons per minute. The combined efficiency of the pump and turbine is 48 per cent, and the machine is arranged so that lubrication can be effected from a level higher than that of the pump, so that it is possible to work satisfactorily with the pump completely drowned.

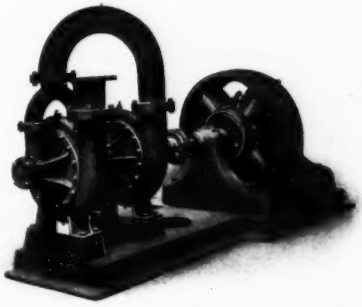


FIG. 24. AN EXAMPLE OF COMPOUNDING BY SEPARATE CENTRIFUGAL UNITS IN SERIES.
Kingsford Foundry & Machine Works, Oswego, N. Y.

High-lift centrifugal pumps directly connected to steam turbines are used in many cases and have shown good results as far as steam consumption is concerned, and are giving satisfactory service. Under favorable conditions a consumption of 22.6 pounds of saturated steam per pump horse-power per hour has been shown on a seven-stage pump delivering 900 imperial gallons per minute under 1,180-foot head, and taking, therefore, about 320 horse power. The turbine was of the Rateau type running at 2,200 revolutions per minute with 90-pounds steam pressure, and exhausting into a jet condenser.

Although high-lift centrifugal or turbine pumps have been on the market for only about nine years in Europe, and four years in America, their use has become widely extended. Such pumps are now commercially available for almost any service, so long as the amount of water to be dealt with is not too small in comparison with the head at which it is to be delivered.

STEEL FRAME BUILDINGS—THE ONLY ONES LEFT STANDING IN SAN FRANCISCO.

THE EFFECTS OF EARTHQUAKE AND FIRE ON MODERN STEEL BUILDINGS.

By Clarence Heller.

A special interest attaches to Mr. Heller's study—the result of personal observation on the ground immediately after the fire—because of his close record of the details of the failure of structural materials and systems under various conditions. His notes were made from the view-point of a trained observer and specialist in structural engineering; and his photographs, taken with the same dominant idea, aid greatly in bringing the facts graphically before the reader.—THE EDITORS.

ON April 18, the buildings of San Francisco were subjected to the violence of two of the destructive phenomena of Nature—earthquake and fire. Only the modern steel-frame structures successfully withstood both, and therefore only they will be discussed at length in this article. At 5.15 o'clock of that morning San Francisco was shaken by the most severe earthquake ever recorded there. The first shock is said to have lasted from 45 to 48 seconds, and it was followed throughout the day by a series of lesser tremors. The steel structures withstood the strains of the vibrations so well that many are already calling these buildings earthquake-proof. This

is as much of a misnomer as designating them as fireproof. They are earthquake-resisting, but should a truly heavy or severe earthquake ever occur, the results would not be very agreeable to contemplate.

The shock referred to caused a perceptible damage to many walls, and to the connections of the floor systems when such connections were bolted. The vibrations of the San Francisco earthquake were horizontal and principally in a northerly and southerly direction. There was no upheaval. The motion caused was a swaying or rocking one, which increased in severity with the duration of the tremor. This caused in the lower floors a wrenching or twisting combined with a rocking motion, and on the higher levels a rocking and swaying. The latter suffered less than the former, which seems to indicate that a structure that is not too rigid or stiff is best adapted to resist the vibrations to which it is subjected. Not the height, but the mode of construction is what determines the safety of the building. It should also be recalled that the frame absorbs the vibrations so that as one ascends the higher levels the acute shakings become less perceptible and the swaying motions more pronounced. The introduction of wind bracing therefore becomes an interesting subject, but will not be treated in this article.

It might be mentioned however that in the Union Trust Building, a ten-story building of triangular shape, every piece of sway bracing was buckled. This bracing was made of 2 by 4-inch channels running through two stories and was placed both parallel and perpendicular to the front of the building. The bending always occurred about 3 inches below the gusset plate connecting the two channels.

So well did the steel buildings stand the shock that no improvements on the present mode of construction can be suggested here, unless it be on the veneer walls. Though in general they acted well, a great many will require repair, and others removal. The tendency was to cause cracks between the tiers or to loosen the bricks. Had the shock been more severe, there is good reason to believe that many of the upper walls on the higher structures would have been shed from the frame. Unfortunately there were not a sufficient number of self-supporting walls encasing these buildings to form an opinion. The photograph on the next page shows how such a wall separated from the frame of the Kamm building at the sixth floor. The damage, however, was probably caused more by the rear of the building being dynamited than by the earthquake. While I have always preferred curtain walls where they were feasible, on account of economy and

SEPARATION OF SELF-SUPPORTING WALL AND STEEL FRAME, KAMM BUILDING.

also superior strength in case of fire, it must be admitted that they are not as satisfactory as walls supported at every floor, because any settlement to the earth, or jar due to earthquake, is liable to injure the foundation in the former mode of construction, requiring the complete removal of the entire wall, as was the case in the building above mentioned; while if the latter method is used any one or more sections of the wall may be replaced without injury to the remaining parts.

In both cases, however, it is absolutely essential that the walls be securely and frequently anchored to the frame, and when they are constructed of stone or terra cotta the individual pieces should be attached to some part of the metal work. Metal copings and cornices have proven preferable to heavy masonry ornamentation, both in respect to safety and economy. In general, the buildings swayed as a whole, though in many instances floors were cracked by the twisting movements. Reinforced floors, whether strengthened by bars or expanded metal, are better adapted to withstand the vibrations and shocks caused by earthquakes than tile construction, and I am confident that in San Francisco the former will entirely supersede the latter in modern structures.

Of the non-fire resisting buildings, the wooden frame houses were least damaged, the principal loss being caused by the falling of chimneys and plaster. These chimneys were for the most part brick, and unfortunately are being reconstructed in the same old fashion. Evidently only the property loss which they caused, and which was very small, has been considered. But are they not a constant source

of danger to life, should another earthquake occur? The next one may occur during the day. These chimneys should be built of concrete reinforced by vertical bars, or if made of brick, the bases should be wider than is now the practice.

While there is no doubt that brick buildings were the most damaged, it is very noticeable that destruction wrought in these structures varied very much even within comparatively small areas. The reason for this is that there was an abundance of miserable masonry. The effect of the earthquake was to crack the walls, starting near the top, or to cause them to sway till at least the upper portions fell out, the roof and floors subsequently collapsing. Walls having frequent buttresses, or cross walls or wide offsets at the base, sustained the least amount of damage. The best example of the latter construction and of exceptionally good masonry, is shown in the accompanying photograph of the ruins of the temple Emanuel, which was erected in 1864—1866. The walls are still standing in perfect condition.

DAMAGE CAUSED BY DYNAMITING. THE REAR OF THE KAMM BUILDING.

Where the walls were well anchored and bonded with good Portland cement, the damage was so very much less than where inferior work had been put in that it is difficult to account for the large amount of poor masonry which existed in San Francisco. It was proven most conclusively that in any kind of masonry, no matter in what kind of a structure employed, to resist either the effects of earthquake or fire,

THE ACTION OF THE EARTHQUAKE ON THE CITY HALL.

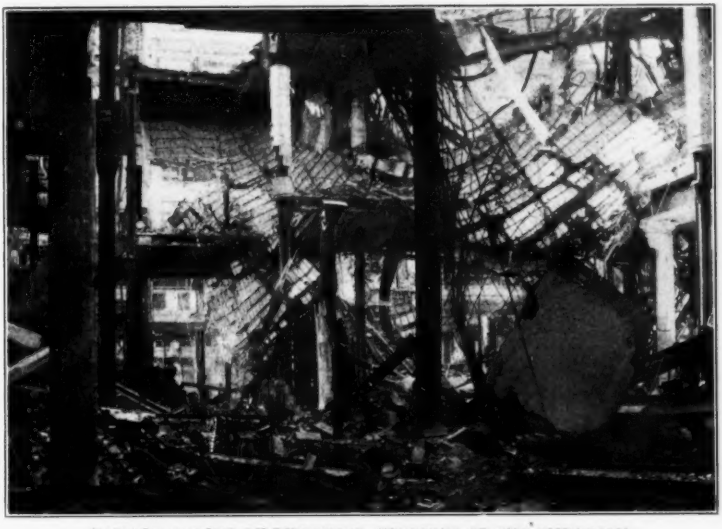
This structure was erected at a cost of $7,000,000, taking years to build and furnishing an impressive example of poor masonry.

EARTHQUAKE DAMAGE TO CHURCH ON GEARY ST., NEAR STEINER.

Another example of poor masonry.

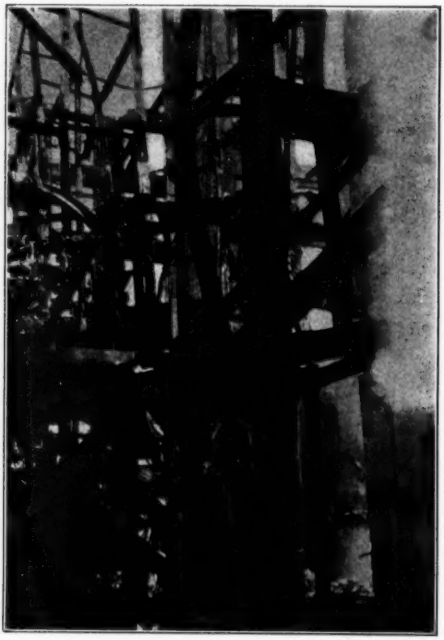
it is absolutely essential that such construction must use the best material, bonded by good cement mortar, held by frequent anchors and executed by the best workmanship.

It has been asserted that of the total losses due to the recent calamity, only 2 per cent was caused by earthquake, the remaining portion being attributable to fire. The latter figure includes destruction by dynamiting, which in some of the steel buildings caused the greatest losses. Fire always devoured all the inflammable contents of the building, but when this was well constructed it left the frame and floors intact; while where dynamite was exploded, it completely wrecked the section of the structure in which it was placed.



DAMAGE CAUSED BY DYNAMITE, INTERIOR OF THE EMPORIUM.
This was a department store with offices above.

The San Francisco building laws recognized two types of structures in which iron or steel was employed—Class "A" and Class "B." The first included "all buildings wherein all external and internal loads are transmitted from the top of the building to the foundation by skeleton or framework of steel, and the beams and girders of which are riveted to each other." "Buildings of this class must be constructed of non-inflammable material throughout" except framing for elevators and staircases. "Wood may be used only for window and door frames, sashes, standing finish—and for upper and under floors and their necessary sleepers." The limit of height for such



STEEL IN CLASS B BUILDING, AFTER THE FIRE.

buildings was 220 feet, and where veneer walls were used the ordinance prescribed that they should not be less than 13 inches thick down to the tier of beams next above the curb level, while below this they were to be increased 4 inches for each additional 14 feet. Curtain walls were also permitted. They had to be at least 13 inches thick for the uppermost 60 feet, and then increased 4 inches for each additional 60 feet or part thereof.

Class B buildings were allowed to be erected to a height only of 100 feet, and were constructed with all the "exterior walls and piers of masonry, or of masonry and steel." All metal work was to be protected as in Class A buildings, but in addition to the wood permitted in such structures it was also allowed to be used for "the floor and ceiling joists, posts, roof boards and partitions." A building of this class resembled very closely those of the "mill construction" variety, except that they usually had steel columns for at least two stories of their height.

Class A, of course, represents the most approved form of construction, the buildings of this type being the only ones that were not a complete loss. Of these there are about twenty-three in the city. Many of the Class B buildings would have reflected discredit on any community, and that many of them were occupied as apartment or rooming houses was nothing short of criminal on the part of the municipality that had approved their planning and erection. Though the fire came unlooked for by the citizens, to those who were familiar with local facilities for combating fire, with conditions in the existing buildings and in those that were being erected—to them it was almost

daily expected, for in the heart of what other large modern city could so many wooden buildings be found, not to mention the many poorly constructed brick houses?

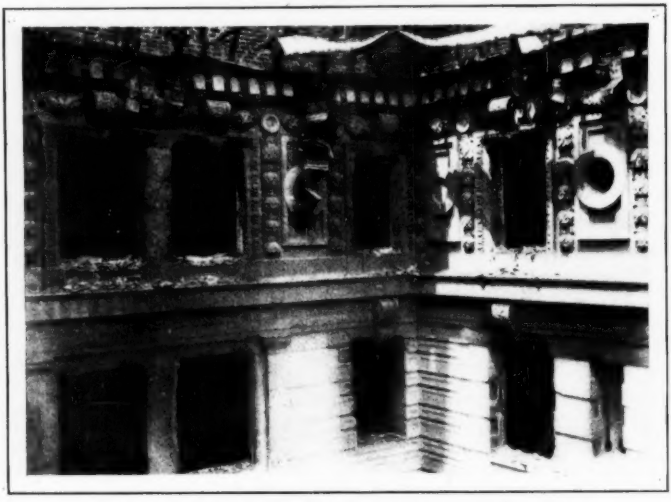
No better example could be chosen to illustrate the necessity of properly protecting steel work with fireproofing materials than the ruins of Class B buildings. Not only are the structures a complete loss, but the steel which was used in their construction suffered so much from the heat that it cannot be redeemed and used in the rebuilding. The remnants of some of these buildings are shown in the photographs. Now compare these ruins with what is left of the Class A buildings. The inflammable materials in the latter are all destroyed, but the frame still stands intact and the floors are still in position. Occasionally a beam is bent or twisted, but usually not so badly that it may not be rerolled. Is it not therefore false economy to erect a building of which steel forms a large part, and not properly protect it nor introduce fireproof floors?

This at once calls attention to the action of heat on the various materials employed in the encasing of steel work. The San Francisco disaster did not afford as good a test for this purpose as the Baltimore fire, for in the Western city the buildings were subjected to an intense heat and then permitted to cool, while in the Baltimore fire they were compelled to withstand both heat and water, causing internal strains. The action of the various materials was for the most part the same. All stone spalled badly, particularly granite. Most of the stone used in San Francisco is a sandstone from Colusa county. Where it

TYPICAL EFFECT OF FIRE ON IMPERFECTLY PROTECTED CLASS B BUILDINGS.

The Terminus Hotel.

came in direct contact with the flames it suffered, like all other stones, but where the heat was more moderate it was not very badly affected. Both brick and terra cotta in exterior walls acted entirely satisfactorily where good workmanship had been employed in their construction.



DAMAGE TO METAL COPING, AND SPALLING OF SANDSTONE.
St. Francis Hotel.

The majority of the floors systems were of reinforced-concrete construction, except in the older buildings where tile floors were placed. Though the tile appears to be of a good quality, floors made of it required removal more often than those of the concrete type. The tiles generally failed by becoming loose and falling, or by the lower face cracking and breaking off. A very important item in the use of tile construction is that the pieces protecting the lower flanges of the beams should be so connected with the voussoir tiles that they should not become detached and leave the lower flange of the beams or girders exposed. Lack of attention in this matter caused the beams to sag, thereby requiring the removal of both floor and beams. The concrete floors were more successful than those of tile, and not only do they resist the effects of fire well, but the manner in which they are constructed makes them better adapted to withstand the irregular motions caused by earthquakes. Cinder and stone concrete proved their value, particularly the former, both when reinforced by bars and by expanded metal.

Partitions of both these substances were wrecked in almost every instance, but where built of terra cotta, the blocks were often available for re-use, whereas when built of concrete the salvage amounted to practically nothing.

The action of suspended ceilings in the San Francisco fire was irregular; in some cases they remained intact, while in others they became detached from the beams. Some manufacturers seemed to consider that no covering need be placed about the lower flanges of the beams if the ceiling were suspended from them. Such construction should not be approved, for should the ceilings fail and the fire still continue, there is then no protection to the beams and their failure means the complete loss of the floor system.

TYPICAL FAILURE OF SUSPENDED CEILING AND TERRA-COTTA PARTITION.

The most important steel members seem to have been the ones that received the least consideration, namely the columns. When a single beam fails it necessitates only the removal of the flooring on each side of it, to the next span of beams, and the beam itself can generally be rerolled and returned to the original position. Not so with a column. If a post buckles or in any other way collapses (and this usually occurs at the lower floors) it either tears the girders connected to it away from their connections, or causes a sag in all the adjacent floor above the injury to the column, which means that the

strut and the floors surrounding it must be removed and then replaced—a very expensive operation. The strength and safety of the floors and walls depend upon the stability of the columns, so that if they are not to receive the best of attention, what object is there in spending much money and time in protecting the less important members of the frame? In all the Class A buildings that I examined, the damage caused by the failure of the columns was greater than that due to all other causes combined. The loss caused by dynamiting will not be considered. It either threw the columns out of plumb, bent them, or damaged them in other ways so as to render them useless. Fire injured the columns only when they were insufficiently or improperly protected, or when the fireproofing shed.

BUCKLING OF A STEEL COLUMN.

Terra cotta tiles gave the best results. When columns were encased in a solid covering of concrete, they suffered no injury, especially when wire netting was bonded in the concrete. However, such solid enclosures were unfortunately seldom resorted to, the most general practice being to place a single thickness of wire mesh or expanded metal around the column and about 2 to 4 inches from the metal, and to envelop this netting with not more than 2 inches of coment mortar. The flames soon destroyed this coating, leaving the column unprotected; or when the fireproofing was not demolished for the entire length of the column, it was partly removed, creating a flue between the column and its covering. No doubt the theory was that the air space thus established would act as a nonconductor. Such air spaces are valuable, as is shown in the tile construction, but in any case it is necessary that there should be some

covering applied directly to the steel itself. When concrete is employed it should be used as a solid mass at least 3-inches thick, or the column should be enveloped in a coating of cinder concrete about 1½ inches thick in which a steel furring has been placed, then an air space of an inch allowed between the first coating and the second. The latter should be at least 1-inch in thickness, and also set on a wire mesh. The outside covering should be anchored to the inner. It is well known that it is advisable not to run piping alongside of the column and within the fireproofing, but many such cases were found. Columns rarely buckled unless subjected to contact of the metal with the flames. It should also be remembered that in office buildings the live load never exists during a fire, so that at such times the columns are called upon to support only about half of the weights they are designed for, which greatly adds to their safety. Where floors supported heavy dead loads and the columns to which they were attached did not have the proper protection, the latter failed while in other parts of the same building, which were used for offices or similar purposes, little damage was done.

SO-CALLED "FIREPROOFING" OF COLUMNS.

The stripping of many columns revealed surfaces much in need of painting, as many had already started to rust, again impressing the importance of proper painting. By far the largest number of columns in the San Francisco buildings were of the Z-bar variety, of which all surfaces are easy of access. The filling of channel columns with concrete might therefore be seriously considered as an extra

security against the starting of corrosion. But when steel receives a sufficient number of coats of metallic or graphite paints, properly applied, there is no reason why rust should form.

Steel columns usually failed by buckling or settling, the different pieces of which they were built separating, while cast-iron columns failed by cracking or breaking. Steel posts generally failed just beneath the connections of the floor girders, and not midway between floors, as might be expected, though such cases, of course, also occurred.

AN EFFECT OF THE EARTHQUAKE.

The only two buildings of any consequence that had cast-iron columns were the old Chronicle building and the Sloan building. The former was the first high building erected in San Francisco; it was put up about the year 1889, and was about nine stories high. The posts were about 12 or 14 inches in diameter. The interior is a total wreck, but the walls stand little damaged, so that the columns in them must also be in good shape. The interior columns evidently collapsed, all the floors going with them. The Sloan building acted differently. It was erected in 1900 and was about 100 by 120 feet and seven stories high. The building had concrete floors, all of which were loaded with carpets, rugs, or furniture. In this building all the posts in the center of the structure settled, from the foundations to the roof, an area of about 50 by 80 feet of floor space being completely demolished from top to bottom. The columns sank as a single shaft, and they do not show a defect until the bases are reached. Here they either broke or melted, but such parts are at present covered up

with debris so that they cannot be examined. I do not think the foundations sank, as a little of the columns can be seen above the rubbish in the basement and shows where they started to bulge. The beams and girders were torn from the lugs by the bolts shearing, and in a few cases by the breaking of the lugs themselves. The entire building will have to come down. I am told by one of the clerks who worked in the building that it did not show any damage after the earthquake, but that it suffered from fire only. The columns did not, of course, all settle the same amount; but all appear to be plumb, which was not the case in the smaller structures. In such buildings the cast-iron posts showed no injury, or they simply broke off. Still, it must be admitted that they stand the heat better than steel. Breaking of the lugs was common. In low buildings, where wooden joists are to be used, cast-iron columns might be employed to advantage, but undoubtedly they should not be considered for any structures of more than moderate height or importance.

Riveted connections again showed their superiority over bolts, especially when called upon to resist twist by earthquake.

No injury to the foundations of Class " A " buildings was found.

It is not the object of this article to discuss the building laws in force in San Francisco before this calamity, but had they been more stringently enforced, and had the property owners been more willing of their own accord to comply with them, the fire might never had such opportunity to spread as it actually found. Not poor material alone, but bad mortar and miserable workmanship, may truly be said to have caused the greatest losses to the property owners of buildings in San Francisco.

TYPICAL FACTORY SYSTEMS, AND THEIR PRACTICAL RESULTS.

By Egbert P. Watson.

BROADLY speaking, there are at present three systems of conducting factories which may be profitably considered; first, the purely commercial, looking to immediate results at the lowest possible cost; second, the mechanical, seeking the largest turnover that the best outfit of machinery can produce, relying wholly upon automatic devices for success; third, a combination of mechanical perfection with certain accessories in the way of provision for the moral and physical welfare of all the employees throughout the works, whether in the clerical department or elsewhere. I say "moral and physical" designedly, for the reason that the new departures in factory surroundings have, most assuredly, a beneficial effect upon operatives who were not familiar with a better way of living than the one to which they had been accustomed—that found in most workshops where the surroundings are only those demanded by law (and not always those), fostering objectionable habits, disregard of the value of property, contempt of authority, and assuredly striking discordant notes in the general scheme which interfere with the plans and anticipations of the projectors of the new order of factory management.

I have mentioned three kinds of workshops especially which are supposed to produce a staple article; but between these there are others which are run upon what may be called the "catch as catch can" plan, in which costs are an unknown quantity and no sort of system prevails; but these need not be considered here, being without the pale of this discussion.

Taking the first group referred to, an example comes ready to hand in one of the largest and oldest manufacturing plants in its specialty in the United States. It gives employment to thousands of persons, but in all that pertains to an amelioration of the old routine already alluded to there is no change whatever. The shops are provided with the best machines and are operated upon day's work and piece-work plans, but in both of these the payment is not more than

will enable operatives to earn an ordinary living in the cheapest quarters and upon the poorest fare; for so soon as piece workers become dexterous enough to earn extraordinary wages, they are cut down in the rate for certain parts and not permitted to exceed about what they could make at day's work. The factory itself is an aggregation of buildings expressly designed for the work to be done, but there is nowhere any other than the usual arrangements for the quartering of thousands of men within doors, and even these are of the most ordinary description and character, and not always in the best sanitary condition. With all this, the place has never come under the notice of the authorities, no attention whatever being given to the conditions by the operatives themselves, who have endured it so long that it has become a matter of course not worth objecting to. It is, perhaps, better to state exactly what the latrines are, for instance; they cannot be called retiring rooms, for there is no privacy whatever in them, a bare room being fitted with a cast-iron trough, or conduit, constantly flushed with water, and this is the sole convenience of the kind alluded to for the thousands of operatives.

When this detail was explained to me by a middle-aged man who had worked in the shop for years I could not credit it, but it remains a fact all the same. Lavatories do not exist, unless a pail of water under the bench can be dignified by that name; these pails belong to the men themselves, but the administration does furnish the water—to both sexes, for the women fare no better than the men. It should be added, however, that this makeshift arrangement is the result of the reckless abuse of much better privileges which were provided by the administration, but it cost so much to keep them in order that they were torn out and replaced by the devices just described.

As a partial explanation of this state of affairs it must be stated that the help is largely recruited from a mixed class of native and foreign-born operatives who are unaccustomed to modern conveniences or any of the usual environments of every day American life.

The immediate surroundings of the factory comprise a few dwellings which are tenantable, but one and two-story houses are the rule; the goat and goose are indigenous and roam over the commons and in the highways; frowsy, unkempt, women quarrel, in strident voices out of windows and over fences, and the whole aspect and impression conveyed to the beholder is depressing to the last degree. They are of all nationalities, " furious Frank and fiery Hun," with a sprinkling of Polacks, Italians, and other races intermingled, who herd together under one roof in this quarter of the town, because

they are birds of a feather, and cannot find rooms elsewhere. There are more beeer shops than groceries, apparently, two hundred, a policeman informed me, within the space of about half a mile square, and the normal conditions of life in this settlement are what might be expected—violence and lawlessness, accompanied at times by manslaughter. The morality of the quarter is on a par with the rest of the surroundings, and the police assigned to it earn their salaries in keeping even a semblance of order. With such examples before them it is not surprising that the best workmen will not live in the quarter, but reside in neat homes of their own far away from it.

This factory is on the fringe of one of the oldest cities in the country, and but a short distance from New York; but, although the administration has ample means at its disposal, no attempts are contemplated looking toward remodeling it.

In striking contrast to the shop just described is another one, but a short distance away, which is modern in every sense of the word. Before deciding upon the completed structure, two experts examined all the leading factories in the country critically, adopting the best ideas in them, and adding to them wherever improvements could be made, with the result, in concrete form, of a workshop which challenges criticism—unless, indeed, it be upon the money expended, this detail not having been considered at all. Marble has been largely used wherever it would add to durability and appositeness, even to the partitions between individual urinals; drinking fountains are installed in the main shops, and certain other features which will be mentioned at some length presently; but this is not the only example of the modern factory, for there are others—so many, in fact, that it would require far more space than a magazine affords to describe them specifically.

When, some years ago, certain enterprising manufacturers began to install radical improvements in their shops, it was looked upon by the more conservative as uncertain—in some sense, dangerous,—tending to disturb the relations then existing between employers and employed, by creating a demand for features in plants which, if generally introduced would cost a great deal in immediate outlay and add correspondingly to the fixed charges for up keep and administration. In a few words, the experiment was subversive, unnecessary, and unpopular; but between the time when pioneers in factory reforms started and the present there has been a great change in opinions, and some of the oldest and most conservative concerns are remodeling their plants, and doubling their capacities, in all lines

of trade, putting in improvements of all kinds which, if they had been suggested on the outset, would have made even the originators of the movement open their eyes in amazement. One thing leads to another in the reform fever, with the result that no expenditure which promises returns is considered adversely.

It cannot be said that this is mere business rivalry, or expensive advertising; but, as the scheme in its entirety is better understood, it has come to be considered by investors, capitalists, and general managers, absolutely necessary to future prosperity. It is, indeed, a long look ahead to provide for the conduct of a factory, years in advance of increased demand for its product, without foreknowledge of what competition, wars, famine, and acts of the common enemy may bring forth; but this very thing is being done at this moment, in many widely separated localities, by stockholders and managers who will never reap any personal benefit from it, many of them having reached the term allotted to mankind; nevertheless they deem it a wise provision to leave their heirs and assigns. An example is found in a recent press clipping:—

> The Waltham Watch Company, with $12,000,000 capital stock, of which $5,000,000 is to be 6 per cent, cumulative preferred and $7,000,000 common stock, will take the place of the American Waltham Watch Company, the capital of which is $4,000,000.
>
> It is announced that the company will build an addition to its present buildings which will enable it to increase its force of employees from 3,500 to 6,000.

Mere increase of size is not the only change impending, either in the works mentioned or in many others contemplating a similar course; unless all signs are at fault, the workshops of the future will differ greatly in tone and atmosphere from those of the present. But right here, if it were not for the fact that discussions savoring of political economics seem out of place, I should be strongly tempted to enlarge upon one aspect of the new movement in factory conditions which I consider to be the key to success or failure in a marked degree; that is, the personnel of the working force. This view is also advanced by some of the best wranglers of the new *régime*, but it will bear much consideration and discussion, in view of the ship loads of raw material—stiff, intractile, human clay dumped upon the American shores weekly, all of which must be re-washed (literally) sifted, and purged of all impurities before it is available in American workshops for even rudimentary processes. How can we expect that natives of many of the Continental countries will appreciate the institutions of the New World, and comprehend what freedom means,

when centuries of oppression and wrongs have upset what few ideas they may have had on the subject? Certainly they will not until they learn to distinguish between liberty and license.

But to return to the main proposition:—in planning a new factory or remodeling an old one, we are careful to see that all the materials entering into its construction shall be of the best quality, testing rigidly the stocks and stones comprising the structure. and employing the best builders to put them together; when the building is completed we install the latest machines and provide conveniences of every sort to insure the comfort of those who are to spend the best part of their lives in running it. We go even further, and supply fixtures and features not demanded by factory laws, so that the workmen may have tangible proof that they are not regarded as part of the mechanical outfit which does the actual labor, but as human beings in whom we have a vital interest, both as regards their moral and physical welfare.

The shop itself is easily kept in good working order at all times, but in the department of labor we are sometimes disappointed in not attaining the results we have spent so much time and money to produce. Our sanitary precautions are not only unappreciated, but actually injured, with malice aforethought, by those for whose benefit they were put in, so much so that the cost of keeping them in order is not small. Painful as it is to be obliged to record these things they must be told in the interest of truth, for this article is not a mere essay upon the topic of which it treats, but is the result of personal observation and conversation with the managers of several modern factories in various parts of the United States and in various lines of manufacture. In all directions I found the same experiences with the actual test of modern systems under working conditions, even where especial pains had been taken in the selection of the help. In the men's departments where most of the trouble originated, complaints of malicious mischief were numerous, but there were none at all in the women's rooms. I said especial pains had been taken in the selection of the help but this should be qualified as I shall show further on by outlining the methods actually taken, and suggesting an improvement in them which would, I think, raise the rating all around, and result in a better average throughout the factory. Just here is the vital point making for success. We are told that a bad workman quarrels with his tools, but I think it should be made more explicit and definite by saying that bad workmen quarrel with *all* tools, and from this aspect of the matter, a

shop full of inefficient or disgruntled workmen is a pretty hard outfit to do business with; but, given good will and good faith upon both sides, the question of the permanency of the new departure in factory administration will be answered affirmatively, in due course. This new system, in short, is by no means an outcome of mere business rivalry, leading firms to endeavor to outdo one another in establishing palatial workshops, for that word describes what some of the latest establishments are in the smallest details. In these latest examples there is no attempt at mere display in certain non-essential departments, where lavish expense in the wood work and wall decorations are made up by parsimony in other rooms, but in gross and in detail the finish is as complete in one place as in another. It must be admitted that this principle runs into money, as the saying is, and a great deal of it, so much so that the observer cannot but wonder at the ability of the persons who planned the building to induce stockholders to produce the funds for it and wait, firm in the power of their convictions, to get dividends. Even superintendents with nearly half a century of successful management of well known plants, who are contemplating doubling their capacity on the modern systems, shook their heads when I showed them photographs of the several departments of a new factory. "Our folks have got plenty of money, but they would never stand for this or that, *never, never, never!*" one said, in very positive tones, for the reason that, being a hard-headed man of plain living himself, he could not be brought to see that a marble partition five feet high between the individual urinals was an absolute necessity in a workshop, or that it had any especial bearing upon the welfare of the individual or the mass, as tending to attract a better class of workpeople to take service.

Be this as it may, those who have established such features know best what their ideals are and how far or when they are likely to be realized, and until they are shown to be impracticable the projectors should not be embarrassed by animadversion. It was not in any unfriendly spirit that the superintendents alluded to commented upon the outfit of the palatial works mentioned previously, but rather as though seeking light upon points which they could utilize in their own improvements.

In further conversation wtih the managers of certain New England factories whose product is known all over the world because of its excellence and low price, I gave the experience of certain factories employing large numbers of work people as to the disci-

pline observed in controlling them, and asked what difficulties, if any, had been found in their own shops, and I was told that there were none of any kind.

"If your people have trouble with their hands," said one superintendent, "it arises from the class of men and women they have to depend upon for their supply of labor. We are in the heart of New England, and have native hands who are by hereditary descent, capable of self-government. They know when they are well-off and do not require to be told what not to do or what they should do; of all things they do not want to be "fathered" too much, or under paternalistic supervision in the shop. Once they understand their duties, they require no watching. If any individual has a grievance of any sort arising from the contact of individual with individual, as will occur even in families at times, they know they have an absolutely impartial judge in myself and they abide by my decision without demur; I have yet to see the first verdict which was appealed from. In proof of this I will mention the labor union question, which was brought up a few years ago, and obtained a certain tolerance from a few hands; but after a full discussion of all sides of the matter in which the union agents had a free opportunity to present their views, our workpeople decided to have nothing to do with it, so we have no unions, but we have an open shop instead, with 'none to molest or make afraid.'

"If capitalists down your way had the same class of men and women to select from, they would have the same results that we do. They ought to come up here and get a few of our "Yankee" girls on their force and they would do better, but I am afraid it would be hard to induce them to leave upon any wages that could be paid them, for some adventurous spirits have tried it upon their own initiative, and returned chastened in spirit with such bad reports of the general conditions which prevailed as to discourage others from experiments. One girl told me that she was present at a public dance to which the conductors of one workshop, having a fine ball-room as a part of its outfit, permitted the help to invite their outside personal friends. At least half of the men were the worse for drink, and one girl as well. This coming to the knowledge of the management caused the public-dance feature to be cancelled.

But as one swallow does not make a summer, neither does one misadventure deter the workshop faculty from continuing their efforts to benefit the class upon whom they have spent their money, yet they have discouragements in plenty if they wished to be influenced by them, and one which recently came to my notice is

unique in the history of such events. Among other departments in the very modern and very beautiful establishment already mentioned is a well appointed restaurant where an elaborate bill of fare is furnished to the whole working force daily, for the moderate sum of 20 cents per capita, which, if obtained outside, would command 50 cents for anything like the same value. In brief, there are two joints to choose from, three vegetables, three pies, soup, pudding, coffee, tea, chocolate, milk, bread and butter *ad lib.*, and certain "tiny little kickshaws" too numerous to be listed, all inclusive for the sum named. After a while, what does my lord Disdain among the help do but circulate a round robin to have the kitchen dispensed with, voided, and made of no avail. For why? Because the cooking was bad! In his previous days of mortification of his stomach because of the leanness of his exchequer, he was fain to fill himself with slabs of rye bread and preposterous cheese, given him if he bought about a quart of sour beer; it was either a feast or a famine with him, and on feast days he fared sumptuously on that precarious edible known as the frankfurter, or the still more suspicious viand called bologna. Square meals are an abomination in his sight, so he will none of them and it is uncertain yet whether he will not carry his point. This is only incidental among the obstacles to the welfare work for the employees which has been encountered; inglorious humorists abound among them, only they are by no means mute,—would that they were!

The splendid swimming pool, over 100 feet long by nearly 30 feet wide, 6 feet deep on one end, with a cemented bottom, flanked upon all sides by dressing stalls built of white marble, is neglected by a large portion of the men, although the water can be heated by steam pipes to any desired temperature, because some say that if they want a bath they can get one at home; this seems rather improbable for the reason that as a rule bathing facilities do not abound in tenement houses.

To enumerate all the eccentricities of men who are given privileges to which they are unaccustomed and which they do not welcome, would take too much space; and, as I have already given much of it to them, I will speak of other features in the line of betterments that are such in every sense of the word and are peculiar to the new departure. Recreation rooms and musical instruments for the use of the employees are certainly laudable upon the part of the management, but, like the purely intellectual features, such as the library and reading room, it demands a certain predilection for such forms of

relaxation to make them useful to the great body of the help. Be this as it may, the facilities are on hand for those who desire to avail themselves of them.

I said in previous pages that I had a suggestion to make in the line of securing a better class of employees (or grade, if class is objectionable) and this suggestion is to change the method of engaging men and women as workers. At present in some advanced establishments, at least, this is to require them to answer certain questions in a printed list as regards their former occupations, place of residence, parentage, why they left their old places, and if they could return to them if they desired to do so; but I see in this an opportunity for prevarication, and incomplete testimony, unless the averments are verified by officers in the management so that there can be no doubt of the truth of them. The only check at present is a duplicate of the assertions made by applicants, which is forwarded to their old employers, with the request that they certify them correct. I can see some objections to this, not the least of them being the fact that their old employers may not desire to have Richard Roe or Jane Doe hire out to competitors, and consequently may color their replies more or less against or in favor of the applicant, to such an extent that they are useless as establishing the facts in any given case. I lay great stress upon this proposed feature of employing new hands, for persons of objectionable antecedents, if introduced among well disposed work people, can do infinite mischief before they are detected and dismissed. The way to prevent this is to institute searching inquiry in the first instance, to which the honest applicant will not object if there is nothing to conceal, but assuredly will very promptly if there is anything that will not bear investigation, thus making further steps unnecessary at once. It may be urged against this plan that it requires considerable clerical labor of a high class, which is a correct inference; but inasmuch as it is exercised but a portion of the time it is not a costly item in the fixed charges. From another point of view it is justifiable, and this is that it aims to furnish a stable working force that can be depended upon, in contradistinction to a floating one which is the bane of all shops.

In making my observations upon this topic in one of the New England plants just mentioned I was careful to note the personnel employed as regards its outward manifestation in the individual and the mass. I went into a boarding house for both sexes that could accommodate 150 persons, and sat at table with them. The fare

was ample in quantity and of excellent quality. The service was quiet and prompt, the table appurtenances, such as linen and utensils, all that was necessary. The behavior of the young people of both sexes was decorous and respectful, each to the other, without any approach to familiarity, least of all to any boisterous behavior on the part of the young men, or inane giggling from the young women; they attended strictly to the business of the moment, and went their several ways when it was over. In the evening I went through the main thoroughfares and found the same attitude in the case of individuals; there were no loitering squads, or gangs as might be said, of young men on street corners, scattering peanut shells and profanity upon all sides; and there was not a single policeman in sight. If this is a New England factory town, I said to myself, it is a pity that it cannot be duplicated elsewhere in the community to the great benefit of the people composing it. It was more: it was an outward and visible sign of the ends the modern factory and its managers strive to attain.

But this was more strikingly manifested in the morning when the workpeople mustered in force. As far as the eye could reach from my point of view on a hotel piazza, the broad sidewalks were crowded with young women eagerly pressing forward "with shining morning faces" on their way to work; singly and in squads they marched, soberly clad in garments suitable to the occasion. Not one had any attempt at cheap finery or was bedizened with gauds of any sort; they looked exactly like what they were,—sober, intelligent, self-respecting young women, self-centered, beholden to no one, calling no man master, animated by a single purpose,—to get to their daily task with as little delay as might be. When the seven o'clock whistle blew there was not a single young woman in sight, they had vanished inside the shop gates "like the airy and unsubstantial fabric of a dream." The whole sidewalk had been occupied by the young women, the men betaking themselves to the causeway upon bicycles; not one that I saw, attached himself to a young woman or attended her to the shop gates. This incident was an object lesson to me, for I realized more fully than ever before what factory towns will be when their plans bear fruit and patience has her perfect work. This will not come in a day or a night, for the abuses of years are not wiped out and forgotten much sooner than it took to create them; but in the fulness of time the frowsy American factory town of today will be supplanted by the thrifty and prosperous one, and the squalid devil-may-care crowds who say in effect: "I go" but go not,

will go actually by the force of the examples set before them by the new factories arising all over the land.

Lest any reader feels that I have spread my palette with too bright colors in this narrative of impending changes, and am over sanguine as to the future, I will say that I know both sides of the factory question—all sides, if I am permitted to defend my statement—for the best years of my life, the early ones, were passed in factories where the conditions were much worse than those which exist anywhere today.

I cannot close this narrative of the aims and, so far, the achievements of the modern factory system with its limited applications in comparison with the large number of shops in the country, better than by mentioning the local pride of the people in the New England town alluded to in the character of the operatives who comprise the largest part of it. When I inquired into their general status and morality there was but one answer: "of the very best." Trolley cars ran frequently during morning hours directly to the works, but they were not fully loaded; how it was at the end of the day I did not see, but was told that many of the young women walked both ways, to and from the shop, both trips, averaging two or three miles daily; if there is to be an universal brother (and sisterhood) of man I feel safe to say that it will have its inception in the town of Waltham, Mass., for the social conditions favor it. The attitude of the operatives toward each other is more like that of the family in its best estate, than of factory "hands" so-called, where the beatitudes are unknown, and everyone's hand is against the other. Philanthropy and business have joined hands with the result that both thrive.

A STUDY OF ELECTRIC-RAILWAY OPERATING COST AND REVENUE.

By H. S. Knowlton.

Comparison between various systems is greatly facilitated by reducing the figures to the unit basis, and in electric-railway work this can readily be done without passing beyond the range of the actual financial quantities which bear directly upon the business transactions between each company and its patrons. The production of transportation is essentially a manufacturing process. Passengers and freight constitute the raw material at the point of departure; by the application of the railway company's equipment, location value is conferred until at the point of destination the finished product stands complete and ready for service. The cost of handling passengers and the revenue thereof, in urban street railway practice, may therefore be analyzed on the basis of the car-mile, the mile of track, the population served or the passenger carried just as in central station operation the cost and returns may be expressed in terms of unit output or plant rating.

THE cost of operating a modern street-railway system and the relation between its earnings, equipment, and traffic, constitutes one of the most favorable subjects for analysis in the field of engineering finance. The facility with which such an investigation can be made depends largely upon the extent to which unit quantities are employed in exhibiting the figures under consideration, and in electric-railway work, more than in any other commercialized branch of applied science, the unit method of analysis corresponds closely in its figures to the actual sums which enter into the business transaction between each company and its individual patrons.

It recently occurred to me that a study of the operating cost and revenue of four representative urban street-railway systems on the basis of the mile of main track operated, the car mile run, and the passengers carried, might furnish material for instructive comparisons. The recently published annual report of the Massachusetts Railroad Commission offers a wealth of material as to the items of total operating cost and revenue of the many street railways in the State, but it naturally does not present much detailed analysis on the unit basis. In the desire to display the results indicated, the system of Boston, Worcester, Springfield, and Pittsfield were selected as representative urban street railways of varying size, and for the purpose of further contrast the typical interurban line between Boston and Worcester was added to the list analyzed. Throughout the preparation of the figures it was realized that statistics of this character applied to systems of diverse conditions cannot be accepted as entirely conclusive

in all particulars, but it is believed that any additional light which can be thrown by contrast upon the cost of electric transportation is worth while.

The Boston Elevated Railway Company's system is one of the largest in the world, and is essentially urban in all its features. At the end of the last fiscal year, Sept. 30, 1905, the company operated 398.2 miles of main track, employed 7,471 persons in its service, and owned 3,325 passenger cars. A large part of the company's trackage lies in the suburban cities and towns immediately surrounding the city of Boston, proper, but it cannot be said that these suburban lines partake in any sense of rural characteristics, for the reason that the Boston suburbs correspond simply to the purely residential sections of any large self-contained city. It is no easy matter to determine the tributary population of so complex a system, which illustrates in its several divisions almost every kind of a route known to the urban electric transportation field--surface, subway, elevated, boulevard, and subaqueous tunnel. The population of Metropolitan Boston, according to the State census of 1905, is more than 1,300,000, limiting this area to a radius of 10 miles from the Massachusetts State House. Probably the vast majority of these people are frequent customers of the Boston Elevated system, despite the strong competition of steam railroads operating in the same territory. At the same time it seems fair to allow only the population of the cities and towns within whose limits the company's tracks are actually in service, and on this basis, the tributary population of the Boston Elevated is approximately 972,000. This method of estimating was followed in the case of Worcester, Springfield, and Pittsfield.

On Sept. 30, 1905, the Worcester Consolidated Street Railway Company operated 138.7 miles of main track, employed 753 persons, and owned 310 passenger cars. The population of Worcester is 128,000, but the consolidated system operates in some seventeen other Worcester county cities and towns which bring the tributary population up to a maximum of 245,000. A considerable portion of the company's mileage is rural, and in many of the smaller towns it is doubtless true that persons living at a remote distance from the company's tracks seldom patronize the cars. At the same time, this number must be only a very small percentage of the estimated tributary population, and when we consider the revolution in rural life which the trolley has helped to bring about, we are probably not going far wrong in counting every inhabitant as one of the tributary population, even though the remote resident may be only a potential patron. Cer-

tainly the occupant of a farm distant two or three miles from a rural trolley line should be counted as a tributary resident, as well as the suburban business man who lives on the very car line of the city system but depends on the faster, less frequent, and more expensive steam railroad service to carry him between home and office.

The mileage of the Springfield Street Railway Company is 87; employees, 500, and passenger cars, 227. This system is largely urban and suburban in character, resembling the Boston Elevated more than the Worcester Consolidated, although on so small a scale that the comparison cannot be pushed very far afield. The population of Springfield is 73,540; the estimated tributary street-railway population 129,000. The Pittsfield Street Railway operates 26.7 miles of main-line track, has 82 employees, and owns 34 passenger cars. Its territory is somewhat like that of the Worcester Consolidated, consisting of the urban centre and outlying radial village or rural sections. Pittsfield's population is 25,000, and the estimated tributary population is 31,700.

The Boston and Worcester Street Railway is probably the most representative interurban line in New England giving high-speed service. It connects the two cities named by an air-line route, and has but two branch lines of any consequence. It operates 73.6 miles of main track, has 230 employees, and owns 67 passenger cars. Excluding the terminal cities, the tributary population of the Boston and Worcester is 93,600; if one included the total population of the terminal cities, the tributary population would be upwards of three-quarters of a million—manifestly an absurdity. It was therefore considered best to omit per-capita statistics in the study of this line, for in my opinion even an approximate estimate of the tributary population is little more than a guess. The company's tracks do not extend into either terminal city, its cars being handled by the local company at each end.

Table I. on the following page gives a general survey of the earnings and expenses of the five systems.

In this table item b covers receipts from carrying mails, merchandise, tolls, rents, and advertising. As would be expected, the great bulk of the traffic is passenger service. Item d includes all general expenses, salaries, wages, insurance, legal expenses, power cost, maintenance, removal of ice and snow, damages, and rents. Item h covers taxes, interest, payments to sinking funds, and similar deductions.

TABLE I.

	Boston Elevated	Worcester Consol.	Springfield St. Ry.	Pittsfield St. Ry.	B. & W. (Inter'b'n)
a. Gross Earnings from Passengers	$12,337,867	$1,362,749	$999,492	$161,465	$443,098
b. Other Earnings from Operation.	351,808	16,266	13,903	120	5,267
c. Total Earnings from Operation.	$12,689,675	$1,379,015	$1,013,395	$161,585	$448,365
d. Operating Expenses	8,617,653	821,679	719,335	115,058	229,655
e. Net Earnings from Operation.	$4,072,022	$557,336	$294,060	$ 46,527	$218,710
f. All other Income	51,893	....	....	50	....
g. Total Income..	$4,123,915	$557,336	$294,060	$46,577	$218,710
h. Total Charges on Income	3,288,831	361,312	151,886	28,724	113,649
i. Net Divisible Income	$835,084	$196,024	$142,174	$17,853	$105,061
j. Dividends	798,000	195,250	156,672	15,000	103,494
Surplus	$37,084	$ 774	....	$ 2,853	$ 1,567

These figures show at a glance the financial operation of the business of each company as a whole, but to ascertain the operating cost and revenue per capita handled, or better, per passenger, we turn to Table II.

TABLE II.

Cents.	Boston Elev.	Worces- Consol.	Spring- field.	Pitts- field.	B. & W.
Gross Earnings per passenger.	5.00	5.00	5.00	5.00	5.00
Other "	.14	.06	.07	.00	.06
Total Earnings from Operation	5.14	5.06	5.07	5.00	5.06
Operating Expenses	3.50	3.02	3.60	3.57	2.59
Net Earnings from operation .	1.64	2.04	1.47	1.43	2.47
All Other Income	.02	....	....	....	....
Total Income	1.66	2.04	1.47	1.43	2.47
" Charges on Income	1.33	1.33	.76	.89	1.28
Net Divisible Income	.33	.71	.71	.54	1.19
Dividends and Surplus	.33	.71	.71	.54	1.19

In this table no attempt was made to carry out the figures to the third decimal place, so that the quantities tabulated are only approximate in the second place. It must be borne in mind that in the case of the Boston Elevated the total charges on the income include the dividends paid to the stockholders of the West End Street Railway

Company in connection with the Elevated's lease of the company's surface lines in Boston.

The volume of traffic and the car mileage of each road in the year ending Sept. 30, 1905, is shown in Table III.:

TABLE III.

	Boston	Worcester	Springfield	Pittsfield	B. & W.
Revenue Passengers	246,941,776	27,722,407	20,093,967	3,245,211	9,110,182
Car Miles	48,069,404	5,079,865	4,806,894	687,299	1,820,575
Tributary Population (estimate)	972,000	245,000	129,000	31,700	.....
Tributary Population per mile Track	2,440	1,770	1,485	1,188	.....
Revenue Passengers per Mile	620,175	199,831	230,920	121,512	123,746
Rides per Capita	254	113	155	102	.....
Revenue Passenger per Car Mile	5.13	5.45	4.16	4.73	5.
No. Employees per Mile Track	18.8	5.4	5.75	3.07	3.1

The Boston and Worcester per capita figures were not attempted. Transfer traffic is not included in the above data.

Tables IV and V show the principal financial items of expense per mile of track and per car mile. It was not thought necessary to present the figures in extenso, the intention being simply to compare items of special operating interest in the different systems:

TABLE IV.

	Boston	Worcester	Springfield	Pittsfield	B. & W.
Gross Earnings from Oper. per Mile Track.	$31.800.	$9,930.	$11,600.	$6,050.	$6,100
Oper. expenses per Mile Track	21,600.	5,910.	8,220.	4,305.	3,120.
Net Earnings per Mile Track	10,200.	4,020.	3,380.	1,745.	2,980.
Operat'g Ratio(exp.-gross) %.	67.9	59.6	71.0	71.2	51.2
Wages per Mile Track	$9,670.	$2,080.	$ 3,030.	$1,292.	$ 970.
Cost Motive Power per Mile Track	2,180.	1,353.	1,570.	1,310.	827.
Car and Vehicle Repairs per Mile Track	1,221.	394.	675.	267.	301.
Car Eqpmt Reprs. per Mile Track	855.	285.	643.	658.	261
Mainten. of Way per Mile Track	1,872.	195.	750.	267.	118.
Mainten. of Line per Mile Track	398.	89.50	175.	4.70	31.20
Legal Expenses per Mile Track	784.	24.50	57.80	57.	.....
Insurance per Mile Track	439.	146.	74.60	37.80	109.
Taxes per Mile Track	2,640.	765.	922.	326.	450.
Dividends (incl. W. E.St. Ry.) per Mile Track	5,000.	1,401.	1,800.	562.	1,400

TABLE V.

	Boston	Worcester	Springfield	Pittsfield	B. & W.
	(All figures are in cents.)				
Gross Earnings ..... per Car Mile	26.4	27.1	21.1	23.5	24.7
Oper. Expenses ..... " " "	17.9	16.1	15.0	16.7	12.6
Net Earnings..... " " "	8.5	11.0	6.1	6.8	12.1
Wages..... " " "	8.0	5.7	5.5	5.0	3.9
Motive Power..... " " "	1.8	3.7	2.8	5.1	3.3
Car Eqpmt Repairs... " " "	0.7	0.8	1.2	2.6	1.0
Maint. of Way..... " " "	1.6	0.5	1.3	1.0	0.5
Maint. of Line..... " " "	0.3	0.2	0.3	..	0.1
Legal Expenses..... " " "	0.6	..	0.1	0.2	..
Insurance..... " " "	0.3	0.4	0.1	0.1	0.4
Taxes..... " " "	2.1	2.1	1.6	1.3	1.8
Dividends..... " " "	4.1	3.8	3.2	2.2	5.6

The foregoing figures are significant in many ways, but only a few points can be touched upon in the remaining space. One of the most striking conclusions to be drawn is the very high cost of street-railway operation in large cities, especially in the direction of the number of employees necessary and the maintenance of way. On the Boston Elevated there are from three to six times as many employees per mile of track as on any of the other systems, and yet the Boston system has a world-wide reputation for able management. It is impossible to escape the conclusion that the enormously greater maintenance of way charge per mile in Boston is largely induced by the city vehicular traffic which is run over the rails in great volume, although high standards of construction doubtless enter the situation. It is interesting to note that although the cost of motive power per mile is largest in Boston, it is also least per car mile in that city. The high cost of power per car mile in Pittsfield is doubtless due to the purchase of power from the local electric-light company.

It is evident that one must know about how many different features of service before attempting to judge the financial performances of a given road. The car-mile earnings of the Boston and Worcester interurban line are excellent in comparison with all the city systems. but this must be due in part at least to the relatively infrequent headway of the interurban cars. The cost of operation on the Boston and Worcester has been kept well down, considering the volume of its traffic. It would seem that the Springfield traffic is somewhat denser than that of the Worcester system, and this is doubtless due to the greater proportion of city track in Springfield.

The figures show very well how the rides per capita increase with the population, as does the traffic density. The low cost of car-equipment repairs in the larger cities is doubtless in part due to their su-

perior shop facilities. It is worth noting than in Boston taxes amount to more per car mile than either motive-power cost, car-equipment repairs, maintenance of way or line repairs, and in no city were the taxes an inconsiderable portion of the operating expenses. The larger the city, the higher were the wages per car mile. This is probably due to two factors: the actual higher usual rate of compensation and the slower schedule speed. It is very plain that on an interurban system increase of traffic is greatly to be welcomed, and probably it is relatively more profitable on a line with a private right of way than on a purely street-railway system. It is important to bear in mind that the profits above the cost of operating a street-railway system in a small city are by no means inordinately great at the present time, and that while a large urban street-railway system properly handled ought to be exceedingly prosperous judged by the traffic density, it requires the most careful management to keep the expenses down to reasonable amounts. Fixed charges, and especially taxes, amount to enormous totals in the operation of a great system; legal expenses and damages, the cost of inspection and wages are bound to be high. The figures presented plainly indicate the increasing complexity of living in the great city as compared with the small community, and they also indicate the wisdom of considering every expense in a transportation system important, even though it appears small in unit items. Wages, taxes, power, and maintenance are the fundamentally expensive items of street-railway service as analyzed herein, but the other quantities tabulated are in no sense negligible. It is hoped that the data presented will be suggestive to those interested in studying the cost of urban electric transportation. A yearly study of any given system along these lines ought to be extremely helpful in determining where the cost of operation may be decreased, and how far short the earnings fall below the experience of similar properties.

THE PRACTICAL ASPECT OF ENTROPY.

By Dr. Jos. H. Hart.

In this article, as in a preceding one upon mechanical refrigeration which we published in May last, Dr. Hart follows the clear and interesting method of using well-known analogies and parallels in mechanics and physics in order to make clear a conception not so easily grasped by the average mind. His demonstration of the significance of entropy will be welcomed because of this clearness as well as because of the importance it has in the fuller practical study of thermodynamics.—The Editors.

TO the majority of engineers, the statement that compressed air contains no more energy than the ordinary atmosphere is apt to prove a matter of considerable surprise; and the further statement that the purchase of compressed air means the purchase of entropy rather than energy brings the average man at once to an interesting but rather hazy subject. The conception of entropy is very incomplete to the ordinary engineer, and while many know what a beautiful and very efficient tool it has become in the analysis of the losses in steam work, very few have any clear-cut, concise ideas in regard to its nature, and its utilization has become in the majority of cases a stilted following of certain simple well defined rules. The reason for this condition of affairs is two-fold. Until recently, very little was known about entropy by anybody, and what was known had little or no practical significance. In the second place, the training of the ordinary engineer was not such as to render easy the acquirement of this knowledge, which was hampered by the technical terms and methods of the physicist and mathematician. At present, however, the conceptions in regard to entropy are clear and distinct, its field of usefulness is gradually and steadily expanding, and it has become indispensable in some of the modern developments of physics, engineering and chemistry.

Now, the entropy of a substance is defined as the ratio of the quantity of heat or energy in a substance to the temperature of the substance. There is nothing radical or unusual in this definition. Similar ones are used every day and present no difficulties in their conception and utilization. Thus the definition of density is that it is the ratio of mass to volume. The constant and steady use of this physical constant, combined with the fact that we have simple and accurate

methods of readily measuring it, have led to an easy realization of its physical significance and use. In the same way, electrical resistance is defined as the ratio of electromotive force to current, and it is only due to its continued and steady use that we have come to conceive of it as a distinct and separate property of matter, analogous to the friction in pipes for a stream of water flowing through them. The importance of having simple and rapid instruments for measurement in such cases cannot be overestimated. Without the ability to measure readily either density or resistance, both of these physical constants would be in a position analogous to that of entropy, and would be equally difficult of conception and utilization. The facts with which we have to deal, however, are that every substance in the universe possesses entropy to a greater or less and varying extent, that entropy is as much a common property of matter as density, resistance, temperature, volume, or pressure, and that we fail to note this property and its often significant change simply because we are unfamiliar with its manifestations and have no instruments for readily and accurately measuring it.

The exact physical significance of entropy is not, even now, fully understood. The favorite method of treating it, from an engineer's point of view, is to regard it as the weight of the heat. An analogue is drawn between the fall of water from one reservoir to another and the fall of heat from a higher to a lower temperature. The work done by the water is the weight of the water times the height of the fall. The work done by the heat is the entropy of the substance times the fall in temperature. Temperature is regarded as heat level, and entropy as heat weight, and the analogy is perfect for working conditions in the temperature-entropy analysis of steam engine efficiencies. It is apt, however, to lead to a confusing situation in the mind of the engineer, to be told that heat is energy, entropy is the weight of the heat or energy, and temperature is the level of the heat or energy.

A much clearer conception of entropy can be obtained from a study of the meaning of temperature, which enters into the definition of entropy. Temperature is known to be proportional to, and for all practical purposes can be taken as identical with, the mean kinetic energy of the molecules. The entropy therefore becomes the ratio between the heat or total energy in a substance and the kinetic energy in the substance. It may be a matter of surprise to most engineers that all the energy put into a body does not become apparent immediately in change of temperature, but this is seldom if ever true,

even if change of state does not occur. Thus if the average kinetic energy of the molecules is increased 20 per cent, this means that the absolute temperature of the body is raised 20 per cent, but it may require an addition of at least several times this amount of energy to produce this change. The excess energy goes into the internal mechanism of the molecule, and is always a definite but varying amount of the whole. In the same way, if a molecule possessing 10 foot-pounds of kinetic energy, or energy of translation, hits the piston in the cylinder of a steam engine and rebounds possessing an energy of 9 foot-pounds, its absolute temperature fall would have been 10 per cent, but it may have given anywhere from 1 to 4 foot-pounds of kinetic energy to the piston. The reason for this is uncertain, but the fact is well known, and the factor by which the apparent transfer of energy in such a transformation must be multiplied to give the real amount of energy available, is called the entropy.

An analogy can best be obtained by considering a train in which the cars are connected by very powerful springs. The springs stretch in starting and a portion of the energy goes into them; the kinetic energy of the train is never the entire energy of the train, and under certain conditions the energy in the springs may become available as kinetic energy when the apparent kinetic energy of the train is changed. Entropy is a property of a body similar to this property of such a train. One can invariably obtain the work available by considering the fall in temperature, the entropy, and the amount of substance involved in the transformation. In this significance—namely, that of a multiplying factor—we may regard entropy, in a sense, as the weight of the energy. Not weight, as is ordinarily understood, but weight as assigned in giving proper importance to a given value.

With this conception of entropy, the entropy-temperature diagram of a steam engine acquires a much fuller significance. The temperature of a substance times its entropy is the total energy in the substance. Changes in either the temperature or the entropy mean change in the total energy of the substance. An isothermal change is represented by a line parallel to the temperature axis; an adiabatic, or an isentropic one, by a line parallel to the entropy axis. Carnot's cycle, consisting of two isothermal and two isentropic changes, is shown by a rectangle whose area is the work done during the change, as in the pressure-volume diagram, or indicator card. The work, however, is measured in heat units and must be multiplied by the mechanical equivalent of heat to transform it into the ordinary units.

Constant-pressure or constant-volume transformations of the working substance produce corresponding changes in the temperature and the entropy values of the substances, and the areas enclosed between the curves and the axes are equivalent to the same amount of work, measured, however, in different but convertible units. An entropy-temperature diagram of a steam engine shows in detail the exact values of the temperature and entropy of the working substances throughout the cycle and shows changes in heat energy during this time, thus telling the exact heat loss, or heat gain, in heat units, at various points in the cycle of the steam. Since the number of heat units in a substance depends on the quantity of the substances, it has been customary to consider the effect in a single pound of the working substance and consider its losses and gains in heat energy, from the boiler back to it.

We have come now to the practical development of entropy. Such a diagram shows absolutely losses or gains and their exact value in heat units, for superheating the steam, for steam jacketing the cylinder, for wire-drawing at valves, for quantity of moisture in the steam, and for initial condensation and re-evaporation of steam in cylinder. Changes in size of pipes, of valve openings, in size and shape of cylinder, in boiler capacities, in the initial and final temperature and pressure of the steam, in the various superheaters, and in the temperature of the condenser and feed water—all these produce changes in the form of the diagram, and the efficiency of each change can be readily shown at once and its value readily balanced against increased cost, without making the ordinary efficiency test for each change. The difficulty consists, however, in making this diagram. We have no instruments for measuring entropy directly. We must, therefore, measure the temperature of the substance at each point in the cycle and also the quantity of heat in it per unit—mass, and calculate the entropy from the definition. The quantity of heat may be measured by calorimetric methods, or it may be calculated if the mass, the specific heat, and the temperature are known. Steam always contains some moisture, and the specific heat of water is different from that of steam and in addition, there is an extra quantity of heat added to produce the change of state from water to steam. A throttling steam calorimeter may be used, however, to determine the percentage of moisture in the steam, and then the quantity of heat per pound of the mixture can be readily calculated. This must be done for every point in the cycle and it has been found easier to use another method.

Certain fundamental relations always hold between the pressure, volume, entropy, and temperature of a gas or working substance. By means of these, given the pressure and volume of the working substance, we can readily calculate its entropy and temperature. The pressure and volume can be readily obtained from an indicator card, and there exist a number of simple graphical methods for doing the computing and thus getting the entropy-temperature curve for the cycle. The volume obtained from the indicator is merely cylinder volume, not including clearance, and the ordinary indicator card must be modified, through a knowledge of the steam consumption of the engine and a pressure-volume steam table, to represent the volume of a pound of steam or working substance. The fact that engineers will go through these rather complicated operations to obtain a temperature-entropy diagram, speaks volumes for the usefulness and efficiency of this device. The invention of an instrument for the direct measurement of entropy would make its use in this connection almost as universal as that of the indicator for valve setting.

Although the application of the entropy-temperature diagram and the conception of entropy is valuable in steam-engine design, its importance is much greater in heat-motor work in general and in every heat-work transformation, wherever it may occur. In steam turbine construction it has become especially important, for the work done in this case is due directly to the kinetic energy of the molecules. The volume and pressure of the steam have not the same significance as in the ordinary engine, and the direct heat losses and gains due to change in temperature and entropy have a much greater influence in the transformation. The effect of change in the size and shape and angle of the vanes, the form and construction of the nozzle, the effect of superheaters and steam jackets, the initial and final temperatures and the humidity of the steam, and the strength of the vacuum in the condenser—all these can be most readily studied by this method and efficiency tests easily made, with a number of factors varying at the same time and each can be readily assigned its proper value. In addition, the mechanical end of the operation in this connection is not difficult. By means of a thermometer and throttling steam calorimeter inserted at regular intervals along the turbine, the temperature and humidity of the steam at these positions can be readily determined. By means of the humidity and the temperature, the heat energy in the steam can be readily calculated, and then the entropy, and the entropy-temperature diagram readily constructed. Slight changes in the work-

ing conditions will then produce changes in this curve which are readily identified and interpreted.

In gas-engine design and theory the conception of entropy and its utilization is equally important. The increased efficiency resulting from the use of high temperature is due as much to the fact that the entropy is greater at these higher temperatures as to the increased range in temperature available. In the choice and suitability of any working substance for heat-work transformations, the entropy is the important factor. It must be high in order that the product of it and the temperature, or the energy per unit substance, shall be high. The best working substance is the one that gives out the maximum energy per unit of the substance for a given fall in temperature. The variation in entropy with the temperature is also an important factor. A large change here with high initial entropy means especial suitability in a working substance for power production. At low coefficient of change with temperature combined with high initial entropy means special suitability for refrigeration. A special study of the entropy of steam and ammonia shows their remarkable qualities as working substances for their respective fields in comparison with other suggested materials. In refrigeration also, as can be imagined, the temperature-entropy analysis of working conditions is productive of remarkable results. Refrigeration deals principally with heat units, so the problem is simple in the system as a whole, but the same difficulties exist in the compressor as in the steam engine. In the construction of the compressor and of the entire refrigerating plant, valves, pipes, condensers, and coolers, the method can be used to advantage and the advantage of various changes is readily tested.

The compressor brings us to the subject of compressed air. This is a poor working substance from an entropy point of view, but it is doubtful, owing to its abundance, whether it will ever be displaced in its particular field of power transmission and energy reservoir. "Energy reservoir" may seem like a contradiction of the opening remark and needs a word of explanation. Compressed air is compressed adiabatically and then cooled off, and the process is sometimes repeated. All the work put into the air results in a rise in temperature, and this work is taken out in cooling it and lost into the atmosphere. In addition, a small extra amount of energy is taken in cooling, for the air finally arrives at a state equivalent to an isothermal compression, and an isothermal line is not as steep as an adiabatic, so the entropy of the air in the compressed state is less than in normal atmospheric condi-

tions and there is really less energy in it, pound for pound. In expanding, the air cools off slightly, on account of a loss in its energy. This is resupplied by conduction from the heat in the atmosphere, and the process goes on until the pressures are equalized. Compressed air is in reality a converter of the energy in the atmosphere, and could not be used if this were shut off. It is analogous to a hole dug in the ground. The hole contains no energy, although energy was used in its construction. Energy can be obtained from it by letting water fall into it through a proper mechanism until it is full. Compressed air is in reality a hole in the entropy, and work is obtained by letting the entropy rise to the common level.

We have mentioned now all the immediate developments of entropy in the engineering field. In physics and chemistry, entropy is equally important. This is due to a general law that the entropy of the universe tends to rise to a maximum. It is related to the statement that the available energy of the universe tends to a minimum. By means of it many chemical reactions can be foretold and explained, and its influence in physical theory and research is much greater. The specialist in engineering physics can also in addition see many future developments for it in engineering fields not mentioned here and hitherto unapproached.

MINING METHODS FOR THE CULEBRA CUT.

By H. M. Chance.

Dr. Chance is so widely known as a sound and able mining engineer that he needs no introduction. The methods he suggests are not hypothetical; they are long proved by successful use. The proposal to apply them at Culebra, however, has elements of novelty and interest making this paper well worth considering. It may prove an important contribution to the solution of Canal problems.—THE EDITORS.

NEARLY all writers who have discussed the proposed canal at Panama, recognize the time and expense required to remove the great mass of material at the Culebra Cut as one of the most serious objections to the adoption of a sea-level type, or of a lock-canal whose base is a few feet above high-tide.

As by reason of its magnitude the task is unique, it appears reasonable to look to methods heretofore unexploited, as well as to those in common use, to reduce this time and cost to within reasonable bounds. As it appears possible that the "milling system" of mining may prove applicable to this work, I propose to outline a plan embodying this system, by which this portion of the canal may possibly be finished in far less time and for many million dollars less than by the methods heretofore proposed.

Many individual scientists and engineers, as well as commissions and other bodies including eminent statesmen, civilians, and specialists, have reported upon the cost of construction and time necessary to complete a high-level lock canal, a low-level lock canal, and a sea-level canal across the Isthmus. Among the engineers identified with this work have been many prominent in civil, naval, and hydraulic engineering works, the personnel of these bodies, including the individual investigators and writers, embracing citizens of almost all civilized nations and representatives of almost every engineering art, except that of the mining engineer. As this work is essentially an open cut—a great hole to be dug through earth and rock—it is not surprising that the assistance of those skilled in excavating beneath the surface has not been utilized; but as the tricks of one trade are often useful in another, it may happen that the art of the miner can profitably be used in this undertaking.

Mining differs from most useful arts in that its functions are destructive rather than constructive, excepting such constructive work as may be auxiliary or preliminary to the destructive process.

In the extraction of ore and in the maintenance of plant deeply buried beneath the surface, the miner deals with transportation, drainage, lighting, and ventilation under conditions unknown in other branches of engineering. All these adjuncts to his work must be so installed as to be safe in the presence of strains and stresses of enormous proportions. The removal of coal or ore from a depth of 5,000 feet or more beneath the surface, the supporting of the overlying formation (whose weight evenly distributed produces a pressure of 5,000 pounds or more per square inch) while the mineral is being removed, and provision for its gradual settlement to a new bearing after the removal of the mineral without widespread disaster, is an example of the problems solved in underground work. The Culebra cut therefore presents no physical obstacles disturbing to the miner, the problems of excavation being interesting by reason of their magnitude, and as affording opportunity for the exercise of three fundamental arts in which the mining engineer is especially trained:—1. Economic and rapid excavation in rock. 2. Handling excavated material by gravity, rather than by manual or mechanical methods, 3. Transportation of large quantities of excavated material.

Neither the dredging of the canal through the soft alluvial deposits of the low-lands nor the excavation of the canal prism through the foot-hills where the rock cuts are of moderate depth, affords an opportunity for the exercise of mining skill; but the excavation of the Culebra cut, involving the removal of 100,000,000 or more cubic yards of rock and indurated clay before a sea-level (or low-level lock) canal is finished, being a task similar in many respects to the mining of great ore bodies, is one which the mining engineer should be qualified to discuss intelligently.

This mass of rock and indurated clay, averaging for a distance of nearly eight miles nearly two hundred, and for a short distance nearly three hundred feet in height (measured from the bottom of a sea-level canal), would naturally appeal to the miner as a gigantic ore deposit which must quickly and cheaply be mined. His first impulse, instinctively, would be to attack it from below—to get under it, and to utilize the force of gravity, rather than steam-shovels or other mechanical devices, for loading the broken rock; and his experience with the "milling system" of mining should enable him to plan for the efficient excavation, handling, and transportation of the material to be removed.

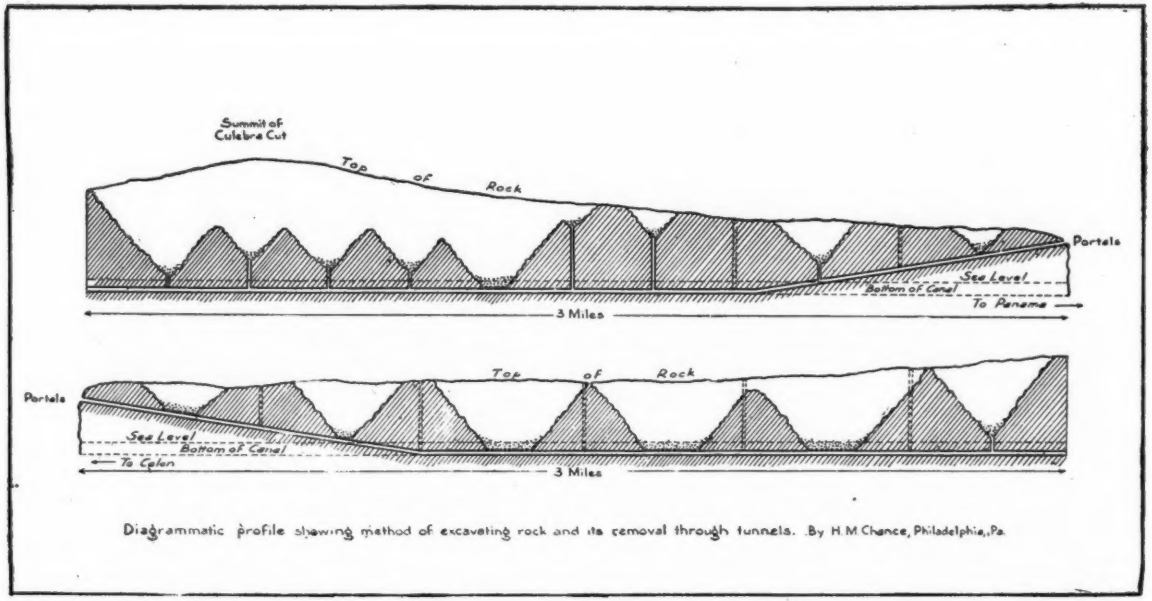
In carrying out this system, the first procedure would probably be to drive tunnels at the bottom level of the canal, deciding possi-

bly upon four single-track horse-shoe tunnels, perhaps 15 feet in width and an equal height, so spaced as to cover the width of the canal at the base, and possibly 30 to 50 feet apart. These tunnels would extend the whole distance, six or eight miles, proposed to be excavated by this method, and at each end would rise by gradual gradients to the surface. They could be quickly driven by sinking shafts at frequent intervals (possibly one-quarter, one-third, or one-half mile apart) along their lines, and driving from the bottom of each shaft in both directions until the headings met. Tracks adapted to the heaviest traffic would be laid in these tunnels, and the shafts would be equipped with chutes and aprons for loading the broken rock into cars as they passed beneath. These shafts and tunnels should be completed in two years, at a cost of about $10,000,000, this expenditure providing handling and transportation facilities for moving 100,000,000 or more cubic yards, equal to a cost of about 10 cents for each cubic yard of total excavation removed through the operation of the system.

The tunnel transportation system, operated preferably by electric traction, might be so planned that in two of the tunnels the trains could pass constantly in one direction, while in the others the movement would be in an opposite direction. Each train upon emerging from any tunnel could be sent to the waste dumps, or to where the material was required for constructing embankments, and upon returning would pass through a tunnel in which the traffic was in the opposite direction from the one from which it came, again receiving its load in passing through this second tunnel and delivering it to waste dumps or embankments at the other end of the work, returning empty to the tunnel from which it first came. By this method of operation the waste material could be equally divided between the Colon and Panama ends; but if a larger proportion than one-half, or if all of the material, was required at either end, one of the tunnels could be used solely for the return of empty trains and the remaining tunnels for loading and transportation. By the use of properly constructed cars the trains could be loaded while moving at moderate speed.

When equipped with sufficient rolling stock, these tunnels should provide for the loading and transportation of 100,000 or more cubic yards of rock per day of two nine-hour shifts.

After the completion of the tunnels, the work of excavation would commence by converting the top of each shaft into a funnel, the excavated material filling the shaft and gradually being drawn out through the chutes into the cars in the tunnels below. As the



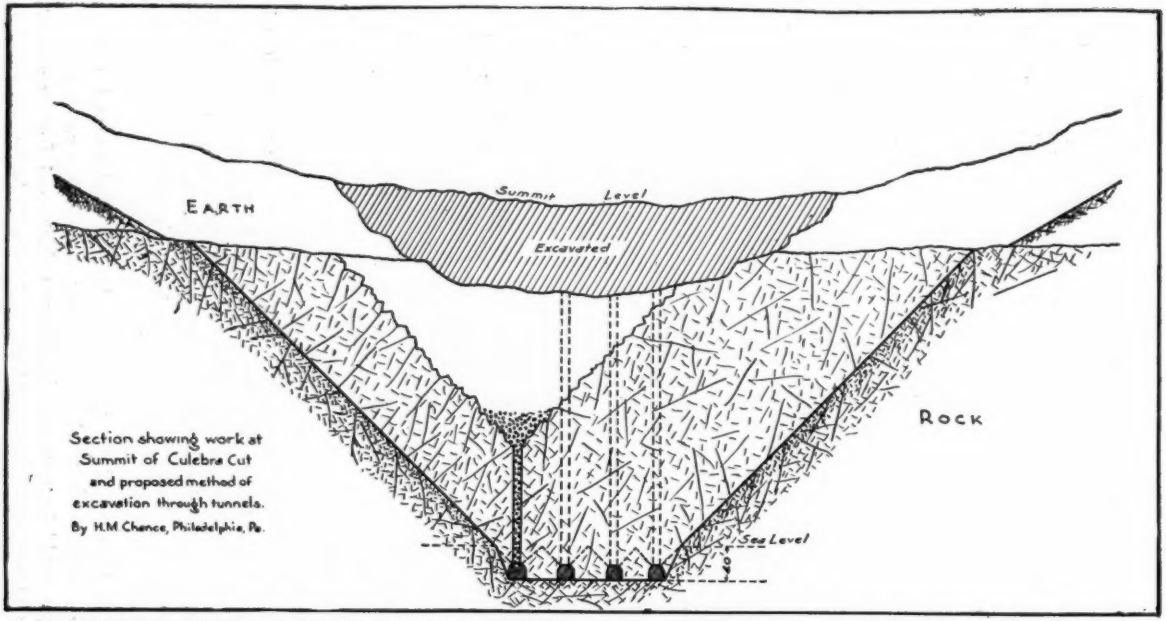
LONGITUDINAL SECTION (DIAGRAMMATIC) OF PROPOSED METHOD OF EXCAVATING THE CULEBRA CUT BY THE MILLING SYSTEM OF MINING, WITH TUNNEL TRANSPORTATION.

excavation proceeded, the site of each shaft would become a great conical or funnel-shaped quarry, the excavations finally reaching the top of the tunnel, and would thereafter progress in each direction as great quarry faces, with proper slope to permit all the excavated material to roll and slide down to the tunnel, there to be loaded through chutes as before described. Such portions of the top of the tunnel as were removed by this process would be covered by timbers upon which sufficient loose rock would always be kept to prevent damage by the falling of large rock masses.

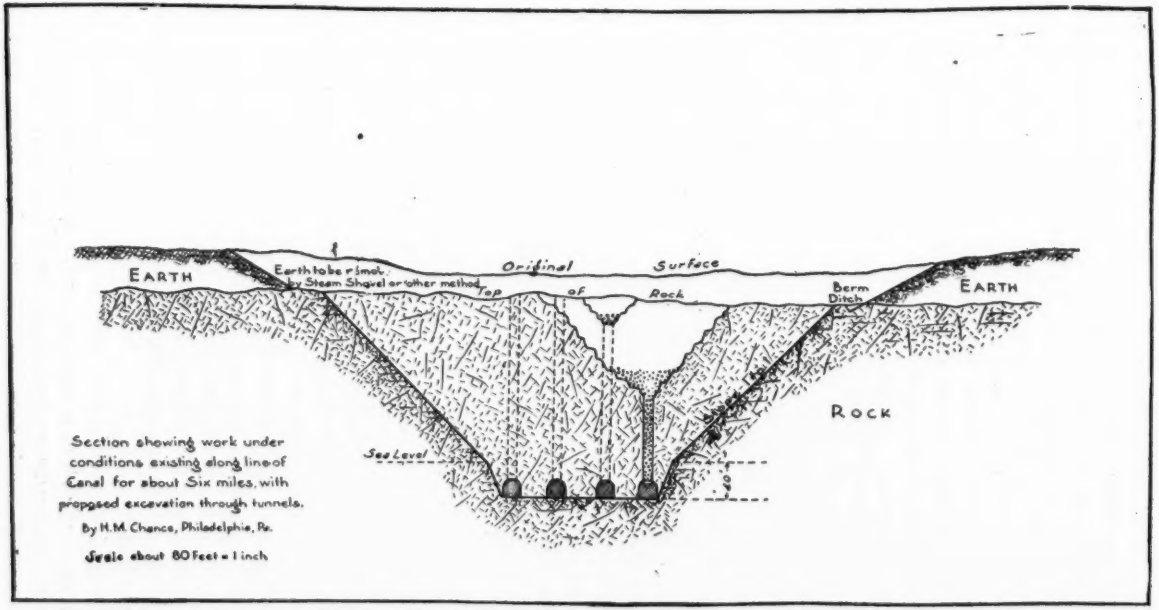
Viewed from an elevated point, the line of the canal would appear as a series of gigantic conical quarries, studded with rock drills busily at work, until having widened each excavation to the full width of the 45-degree or other side-slopes of the canal prism, the drills would continue excavating in line with the canal axis, gradually converting these conical quarries into oblong wedge-shaped cuts, until each meeting its neighbor and the barrier between removed, the canal prism would be complete excepting only the removal of the small pillars lying between the tunnels and above the tunnel roof.

Throughout the prosecution of this rock cutting, the visitor at the surface would see nothing but an array of rock drills, drill runners, helpers, and shot firers. No plant would be there excepting the drills and lines of pipe for steam or compressed air, and a series of light ropeways and derricks for handling the drills. As contrasted with the systems in common use, in which the excavated material is handled with steam-shovels, derricks, or mechanical conveyers, this method would eliminate the hundreds of steam-shovels with their thousands of attendants, the armies of track-layers and shifters, the hundreds of locomotives and miles upon miles of tracks, side-tracks, and switches, which must interminably be shifted and rebuilt, often with adverse grades, and which are more or less obstructed and perhaps damaged by every blast. With steam-shovels, cars, locomotives, and tracks, in addition to drilling apparatus, scattered throughout the work, blasting must always be cautiously done, with charges of moderate size; whereas the plan here proposed permits the use of as large charges of explosives as may be found most efficacious.

With a transportation system capable of loading and moving 100,000 or more cubic yards per day, the 100,000,000 cubic yards of excavation could be removed in between three and four years, for loading and transportation could proceed even in inclement weather, sufficient excavated material lying in the bottom of the quarries to



DIAGRAMMATIC CROSS SECTION SHOWING THE PROPOSED MILLING SYSTEM WITH TRANSPORTATION TUNNELS, FOR EXCAVATING THE CULEBRA CUT.


EARTH
Earth to be removed by Steam Shovel or other method
Original Surface
Top of Rock
Berm Ditch
EARTH
ROCK
Sea Level
Section showing work under conditions existing along line of Canal for about Six miles, with proposed excavation through tunnels.
By H.M. Chance, Philadelphia, Pa.
Scale about 80 Feet = 1 inch

THE SAME AS ABOVE, BUT SHOWING THE APPLICATION TO THE HEAVY CUTS APPROACHING THE CULEBRA SUMMIT.

To simplify these drawings, the shafts are shown located directly on the lines of the tunnels. A preferable method might be to locat them in the pillars between the tunnels, and connect them with the tunnels by inclined loading chutes.

keep the transportation system at work. Whether the rock could be excavated at equal rate is a very different question.

In the earlier stages of the work such rate of excavation probably could not be attained, and possibly during the first year the average rate could not be expected to exceed 20,000 to 40,000 cubic yards per day; during the second year, 60,000 to 100,000 cubic yards; and thereafter 100,000 or more cubic yards per day, requiring perhaps five years or more for the excavation of the whole prism. It is of course difficult if not impossible to predict in advance the rate at which this rock excavation can be performed, but there would seem to be small doubt that drilling and blasting could proceed far more rapidly under this method than when the work is obstructed by steam-shovels or other mechanical excavators, tracks, sidings, switches, cars, and locomotives.

The capacity of this tunnel method of excavating, loading, and transporting is so large that provision for prompt unloading becomes an important function, but efficient plans for disposing of the excavated material are essential to rapid construction irrespective of the methods employed in excavating and loading.

Computations may be made approximately showing the economy to be realized by replacing the steam-shovel or other mechanical methods by this tunnel method of excavation, and in making such estimates it is not necessary to deal with those items of cost which are common to both.

We may therefore compute this economy by adding to the cost of loading the broken rock by steam-shovel or other mechanical method, the wear and tear and depreciation in value of such machinery; the cost of laying, maintaining, and shifting car tracks, sidings, and switches; the cost of switching, car shifting, and transportation in the open-cuts, above the cost of car handling in tunnels; and the increased cost of explosives and drilling when using other methods, and deducting from this sum the first cost of tunnels.

Such computations indicate a net saving of not less than 25 cents per cubic yard—an aggregate net saving of $25,000,000, if the rock necessary to be removed be taken as 100,000,000 cubic yards, and a correspondingly larger amount should the material to be excavated exceed that quantity.

In the operation of this tunnel method of excavation, the installation of an automatic block system to control transportation, of telephones, safety apparatus, and chute mechanism to control the loading chutes, and of electric pumps and other devices common in mine and tunnel work, would form essential portions of the plant; and the

construction and maintenance of pumps, auxiliary rock-chutes connecting with the main shafts and cuts to avoid removal of the whole tunnel roof, of shafts for exit and entrance and for air, of cross-cuts from tunnel to tunnel, and complete and efficient apparatus for ventilation and other minor appliances, would also be indispensable adjuncts which it is unnecessary to discuss in detail, the combined first cost of these adjuncts and their maintenance being apparently several million dollars less than the first cost and maintenance of the surface plant displaced or rendered unnecessary by the adoption of this method. Nor is it essential to discuss the devices and methods of operation to prevent blocking of the shafts and chutes by rock of large dimensions, nor for sustaining the weight of loose rock in shafts and chutes, as these difficulties have been overcome in operating mines by the "milling system;" my present object is merely to indicate briefly and clearly a general method by which it appears possible that the excavation of the Culebra or other similar excavations can quickly and cheaply be made.

The drawings illustrating this article are not intended to show a shape or form for the canal itself—which would probably be walled with nearly vertical walls and have a wide road-bed (tow-path) on both sides a few feet above the water-level, or be finished in accordance with such plan as those in charge of the work might deem most convenient or desirable—the sketches being mere diagrams made solely to illustrate the text of this article.

The "milling system" of mining is applicable only where the quantity of material to be removed is large. Few ore-bodies are of sufficient width and depth to permit its use, but under favorable conditions it is recognized as the cheapest known method for excavating and removing rock or earth. It has been profitably used on a large scale at the Treadwell gold mine in Alaska (where an open cut over 1,000 feet long by nearly 400 feet deep and 450 feet wide was taken out by this method) and at the Homestake gold mine in South Dakota, also in iron-ore mining on the Mesabi range, (where however the depth of the workings was not sufficient to realize the largest economy), also in a few instances in iron-ore mining in the Southern States, in gold mining in South Carolina and Georgia, in mining thick coal-beds in the anthracite coal-fields in Pennsylvania, and doubtless at many places at operations with which I am not familiar. There is therefore nothing new or experimental in these suggestions, excepting the proposed combination of a series of parallel tunnels and shafts with this "milling system" of mining to adapt it for use under the conditions present at the Culebra Cut.

EDITORIAL COMMENT

THE Senate, on June 21, passed the bill providing "That a lock canal be constructed across the Isthmus of Panama, . . . of the general type proposed by the minority of the Board of Consulting Engineers, created by order of the President, dated June 24, 1905. ." In an unexpectedly swift climax of victory, the lock plan has prevailed—the plan which, throughout, THE ENGINEERING MAGAZINE has consistently advocated and urged. To this we have bent our best effort and energy, ever since the adoption of the Panama route ended finally our former fight against the Nicaragua project.

General Abbot's leading article in this issue, therefore, might appear to be a shot fired in signal or celebration of victory won, rather than one taking part in the fight. But though late in reaching the public ear, it was, in fact, one of the strong forces in the last great battle upon the floors of Congress. Advance copies, placed three weeks ago in the hands of the leaders of debate, played an effective part in the struggle. The General has helped once more in winning a triumph of no small significance and value to the country—a victory this time in the constructive arts of peace.

It is a most welcome pleasure to us thus to have rounded out and completed a record of ten years' service in the interest of "the best and most practicable route and plan for a ship canal across the Isthmus of Panama", as our judgment and our conscience directed.

This record, beginning with Mr. Going's disclosure of "The Absence of Facts about the Nicaragua Canal", in June, 1896, and now crowned by General Abbot's able and convincing reassurance as to the safety and merits of the lock-level projet on the Panama route, comprises a series of more than eighty contributed articles, reviews, and editorials, covering every phase of the question and pointing steadily to the conclusion now endorsed by both Federal legislative bodies. It is far too long a record for detailed review here, but some brilliant points may be profitably recalled. Early and significant among these stand the admirable series by W. Henry Hunter, chief engineer of the Manchester ship canal and late member of the Board of Consulting Engineers. His study of the economic influence of the ship canal, and his clear comparison of the Nicaragua and Panama propositions, did much to lay a strong foundation for sound public opinion on the questions at large. Next came the monograph by Charles Paine, past president of the American Society of Civil Engineers; his summary of the "Actual Condition of the Panama Canal", appearing in February, 1900, threw fresh and true light upon the status and value of the great undertaking which the French up to that time had been developing.

Our editorials on "The Unseemly Haste of the Nicaragua Advocates", and General Abbot's "International Aspects of the Panama Canal", with many other papers and discussions of collateral phases of the problem, carried on during the next two years the fight for careful study before decision. Again, editorially, in the summer of 1902, we urged most strongly the exercise of common-sense before taking any binding action upon vital points—the cause at this time being in particular the proposal to turn to Nicaragua on account of the unreasonable temper of a single official of the French company, and the sequence being the satisfactory acquirement by the United States of all

the desired rights at Panama. Then, in 1902 and 1903, followed the notable debate in our pages between General Abbot and the late George S. Morison, bringing out the relative merits of several variants of the lock plan, and most particularly that of "the general type proposed by the minority of the Board of Consulting Engineers" and now accepted by the country.

This was followed closely by other contributions from General Abbot, widely recognized as the greatest living student of the problem of the Chagres:—"The Solution of the Panama Canal Problem" and "Conditions Affecting Building of the Panama Canal"; in sequence with these were contributed to our pages also important studies by members of the earlier Commissions—especially, Professor Burr's "Present Aspects of the Panama Canal Construction Work", and C. E. Grunsky's "Work of the Commission on the Panama Canal", (February, 1905), this latter being given to THE ENGINEERING MAGAZINE under the direct auspices of Admiral Walker, chief of the first commission charged with the construction of the great waterway. In this same number appeared our editorial upon "The Weight of Authority in Favor of the Summit-Level Type", which, followed and supplemented by further editorial comment throughout the past sixteen months, has made THE ENGINEERING MAGAZINE the leading advocate in the cause now so favorably decided.

Later, but by no means less significant, came the widely noticed series by John F. Wallace, late chief engineer. His articles, which ran from September, 1905, to March of this year, summed up the total experience of a man who had been for more than a year on the ground, in direct charge of the practical work, and face-to-face with "all the conditions there are." They made an able, honest, and fearless analysis of the dangers and defects of our National effort at constructive work, as well as pointed the way to the policy which would make certain its successful accomplishment.

It has been a long fight and a strong one—sometimes tinged with bitterness, but (with few and isolated exceptions) waged between honorable and conscientious champions on both sides. The great preliminary problems are settled, as we believe, soundly and wisely. The next question which must be answered, and answered rightly, if the work is to succeed, is that touching the mode of construction. In this it shall be our part to advocate, with all the earnestness and conviction we can command, the execution of the work by the contract system, in accordance with plans prepared and under supervision directed by the Government. Once more, as in the case of the choice of route and of the choice of general plan, it is to be anticipated that the first impulse of the public will be in opposition. Once more, we believe, honest study and clear statement of fact and experience, and fair deduction from precedent and example, will direct the enlightened common-sense of the people to the proper choice. In this, as in the questions already disposed of, we shall not fear to lead whither conscience and judgment direct, confident that the great body of our thinking countrymen will quickly hear, heed, and follow the same leading voices.

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We have referred more than once in these columns to the influence which the work of the engineer has had upon the solution of economic problems, and a very moderate degree of attention directed to this feature in modern industry will reveal innumerable examples of this relation. Thus, the modern tall building, itself as much an achievement of the engineer as of the architect or the business man, did not come into being until the development of the elevator made the use of upper floors a physical possibility. Even with the use of the hydraulic lift, buildings of more than eight or nine stories did

not become general until the widespread introduction of the telephone made it practicable for a man to transact more business without leaving his desk than had formerly been possible by the combined use of the mail and his own legs.

It is a trite saying that railways have transformed commerce, but it is not so fully realized that with the improvement of communication in a thousand ways, by the telegraph, the telephone, the pneumatic tube, and even the mail chute, business has been facilitated, effort concentrated, and human energy conserved and directed.

Formerly a large element in commercial success was the ability to purchase a commodity in a place where it could be had cheaply with the opportunity of transporting it to a locality where it could be sold at a large advance, the profit depending largely upon the ignorance of the true value by the purchaser; but today the markets of the world are placed simultaneously before the purchaser and seller alike by reason of scientific methods of communication.

In like manner with the control and direction of human energy, the engineer is combining and controlling mechanical energy and directing natural forces. Already the development of the "white coal" of Italy, Switzerland, and France is diverting industry from centres originally created and still maintained by the diminishing supplies of fossil carbon. With the recognition of the fact that the true function of electricity is that of a transmitter of mechanical energy, there has come an industrial development which is necessarily causing economic methods to be profoundly modified. The possession of local power facilities, or of water-transport, no longer controls absolutely the situation of industrial establishments, any more than the position of tools in the shop is determined by the position of the line-shaft; the power is brought to the tool and, in many cases, the tool to the work.

In view of such developments it cannot be emphasized too strongly that the engineer himself should be a business man—that in all his work its influence upon business methods should be appreciated, and that his training should include such a broad appreciation of his relation to the work of the world as to cause him to realize his position as an economist. Even when the sad exigency of international dispute renders conflict inevitable, the engineer must fight the battles either afloat or ashore which determine the issue in question, and neither in peace nor in war can the nation which fails to use the services of the engineering profession hope for either temporary or enduring success.

* * *

It appears that the appropriation for the Geological Survey for the purpose of continuing and completing the testing of American fuels, and the extension of this work to the investigation of materials of construction, is in danger of being cut off. Since engineers and manufacturers in all parts of the country are strongly in favor of the continuance of this important work, it is to be hoped that they will strengthen the hands of those members of Congress who are endeavoring to have this appropriation restored, and use every means in their power to convince the committee of the great mistake which they are in danger of making. We have already expressed our own favorable opinion of this fundamental investigation, and trust that such a valuable series of original data will not be mutilated by being left in an incomplete condition.

REVIEW OF THE ENGINEERING PRESS.
"THE WORLD IS ITS FIELD"

UNSOLVED PROBLEMS IN METALLURGY.

RELATIONS OF METALLURGICAL RESEARCH TO THE GENERAL DEVELOPMENT OF THE APPLIED SCIENCE OF ENGINEERING.

R. A. Hadfield—Institution of Civil Engineers.

EVERY department of engineering has its unsolved problems, but in view of recent developments it appears altogether probable that the work of the metallurgical engineer includes about as open a field for the ambitious investigator as could be desired. In the fourteenth James Forrest lecture, before the Institution of Civil Engineers, Mr. Robert A. Hadfield, known on both sides of the Atlantic as an earnest and successful student of metallurgical phenomena, discusses the problems immediately confronting the engineer, and his address is alike stimulating and encouraging.

Mr. Hadfield practically confines himself to that department of metallurgy with which his own name has been so closely associated for the past twenty years, the metallurgy of iron and steel, beginning with some statistical data to show the enormous magnitude of these industries.

"To give some idea of the gigantic nature of the operations of the metallurgist, and to show the enormous demand for iron, it may be mentioned that the estimated value of the world's products of iron and steel is now not far short of £1,000,000,000 annually. The output of pig iron for 1905 was 53,000,000 tons, which is just double the production of 15 years ago, and of this probably 80 per cent is turned into steel. The total iron ore extracted yearly throughout the world is almost one hundred million tons. The pig iron production in the United States last year was 23,000 000 tons, or 4,000,000 tons beyond any previous record. Of this the state of Pennsylvania alone made nearly three-quarters of a million tons more than the whole of Great Britain.

"Notwithstanding the enormous strides made by other countries, the United Kingdom still holds the field in having produced the largest cumulative quantity of iron. We also yet export far more iron and steel than any other nation; twice as much as the United States, and nearly 50 per cent more than Germany. This is not a little remarkable in face of the statements made by some who are continually predicting our decline.

"Until recent times the manufacture of iron was carried on empirically, but since its production has been guided by the light of modern scientific knowledge the world's civilisation has progressed by leaps and bounds. Under the conditions of modern life the consumption of iron per head of population is an excellent index of the material prosperity of a nation. In America this has now reached the high figure of 619 pounds per head, as compared with 387 pounds in 1900, or 84 pounds in 1856, just half a century ago. The world's total production of pig iron in 1905 was 53½ million tons, representing an average consumption of about 68 pounds per head.

"It is unlikely there will be any halt in the enormous demand for iron. It is quite probable that by the end of the century, if the present ratio of increase continues,

there will be a call for over 500 million tons of iron ore annually; for we must remember that, in addition to existing areas of consumption, Eastern nations will, without doubt, before long enormously add to their demands. This naturally raises the question—Will our sources of supply run short? It is a problem which time alone can determine. It can, however, almost with certainty be foreseen that the known iron ore fields of North America, Germany, and England will be exhausted within one or two centuries from now."

After discussing the properties of iron in its pure state, Mr. Hadfield shows the great extent to which these properties may be modified by special treatment. A fraction of one per cent of sulphur destroys the malleability when hot; the presence of carbon lowers the fusing point by several hundred degrees. Hardened carbon steel has ten times the hardness of the iron of which it is mainly composed; while the electrical resistivity is also increased tenfold by the addition of nickel and manganese.

"In its qualities under mechanical tests the changes are equally profound. Its elastic limit in the pure state is about 10 tons per square inch; this can be increased to over 100 tons in nickel-chromium steel. Similarly the tenacity, originally 19 tons per square inch, or even as low as five tons in cast iron, can be increased to 110 tons per square inch, or if wire-drawn material is considered, to over 200 tons per square inch. I have produced a nickel-carbon steel (carbon 0.41 per cent, nickel 20 per cent), not wire-drawn, which when tested in liquid air had a tenacity of 154 tons per square inch, with 15½ per cent elongation. The ductility or property of elongation of iron may be practically nil, or increased to over 70 per cent in the case of certain iron-nickel-manganese alloys. With such an extraordinary range of qualities it can, indeed, be said there is no other metal known which is so curious and at the same time so valuable to mankind."

All these remarkable variations in the properties of iron and its alloys are to be attributed to various forms of crystallisation and it is to the introduction of the microscopic study of the physical constitution of the iron alloys that our progress in their metallurgy is mainly due. In this connection the pioneer work of Dr. Sorby, as long ago as 1857, must be recognized, the development of these studies, in the hands of later workers, having been of the greatest importance.

The whole art of producing steel of high quality consists in obtaining and controlling the type of crystallisation desired.

One of the most important factors is that of temperature, but until comparatively recently there were no means of checking this; we had to depend on the eye alone. This human instrument was too uncertain, except when working with special brands of steel, such as tool steels, these usually being bars of small dimensions, and dealt with in the smith shop. Many irregularities arose in the early studies of special alloy steels, and without our present knowledge of their heat treatment, and consequent control of crystallisation, these alloys would be practically useless.

Mr. Hadfield discusses the important influence of heat treatment upon steel, and the consequent value of modern pyrometers in enabling the accurate determination of high temperatures. The metallurgist of today must also be a physicist, skilled in the use of instruments of precise measurement, including the extension of their applications far beyond the limitations of the physical laboratory.

"There are many unsolved problems to be worked out in connection with the production of steel. The Bessemer and Siemens-Martin processes have been carried to a great refinement, and the material produced by them, as regards quality, holds a high place in engineering construction, whilst the rapidity of production and low cost they have made possible are economic advantages of a high order. Beyond improvements in detail, none the less important because they are small, these processes remain in principle much as they were originally. It will probably be a long time before they are supplanted.

"There are those who look forward to an electrical method of producing iron and steel. If any practical system of this nature for converting iron ore into pig iron or steel could be introduced, using the stored-up powers of Nature instead of burning carbonaceous fuel, the revolution

in practice would be great. Probably over 100 million tons of coal, equal to about one seventh of the world's total output, are used annually in the smelting of iron, to say nothing of the further large quantities employed in the subsequent working of iron and steel into more finished form. Where water power and suitable iron ore can be found together, then, no doubt, satisfactory electrical smelting practice will be developed, but this can only come slowly.

"Pioneer work is being done in Sweden, France, and Canada, in electrical smelting for the production of steel, but unless water-power can be obtained at economical rates it would seem that the application of this system must remain very limited; that other sources of power should be used at present appears out of the question from an economical point of view. Moreover, the electric furnace does not purify steel more than other furnaces not specially adapted to that purpose. Bad steel can be produced by it as easily as by the ordinary processes. Some of us know how often the old type of crucible steel smelting, so largely practised in Sheffield, has been threatened with extermination, but more material is now produced in this way than ever before. The electrical system has in this older method, notwithstanding its extraordinary wastefulness, a competitor that will not soon be annihilated. There is no magic in the electrical method as it would seem some would have us believe. Steel made by it shows similar analysis, and has the same physical qualities as that produced in other ways."

Mr. Hadfield naturally refers to the alloys of iron and manganese with which his name has been so closely identified, and this alloy seems destined to create some remarkable results in the modification of materials of construction.

"In the brittle iron-manganese alloy containing 4½ per cent manganese, the properties of iron seem quite reversed. Although the carbon present is comparatively low, yet this alloy is more brittle than cast iron. With an increase of manganese to about 12 per cent the properties of this alloy again entirely change, and it becomes of more than ordinary interest. When forged and treated, this steel has a tenacity of about 60 tons per square inch, with a ductility of 40 per cent to 50 per cent, or considerably more than that of pure iron. Yet the determining factor, manganese, is in itself an exceedingly brittle metal. It also becomes practically non-magnetic, and, unlike certain nickel-iron alloys which also appear to be non-magnetic, but are reversible, it cannot be rendered magnetic even by quenching in liquid air, nor does ordinary heating render it magnetic. When it is considered that the same metal, manganese, combined with copper and aluminium in the material known as the 'Heusler' alloy, gives a magnetic product, although no iron is present, it will be recognized what a wonderfully wide field for research is offered by alloys of various kinds. The results to be expected are so curious that it is not possible to generalise from one to another; each alloy must be worked out."

The constructing engineer is naturally interested in the actual properties of his materials of construction, apart from the method by which those properties are obtained, and this leads directly to the broad field of the testing of materials.

"We here enter upon a domain in which the civil engineer is largely interested. Whilst he may not in a direct form concern himself so much about the manner in which the material brought to him by the metallurgist is produced, he now takes great interest in its properties. He inquires how it will stand in every-day service under shock, wear and tear, atmospheric influence, and other conditions to which it may be subjected. He properly says: 'These wonderful tests are very well, but can you always produce them regularly? Is the material economical in practical use?' He also asks other questions of a like nature. He must not be too exacting, however, for a friendly word of encouragement from the user to the metallurgist has the greatest influence in spurring him on to meet the increased severity demanded by modern conditions, even if he at first fails. Bessemer's first rails were laughed at, and yet today statistics tell us there are 525,000 miles of single track of railway in the world, or a total length of considerably over 1,000,000 miles of rails. This means there is a total of about 71,676,000 tons of rails in use at the present time, most of them made by Bessemer process."

TEMPERATURE CONDITIONS IN UNDERGROUND RAILWAYS.

EXPERIENCES WITH THE DEVELOPMENT OF HEAT IN THE OPERATION OF ELECTRIC RAILWAYS IN CITY TUNNELS.

H. Kayser—Gesundheits Ingenieur.

IT is always well to endeavor to profit by the mistakes of predecessors, and it is interesting to note that in Germany the question of proper ventilation and cooling is being considered in connection with proposed tunnel railways, in view of the somewhat unexpected results which have developed in the New York subway and the Paris Metropolitan. In an article by Inspector H. Kayser, in a recent issue of the *Gesundheits Ingenieur* the whole subject is discussed in the light of American and European experiences, with suggestions for the abatement of the heat-difficulty in connection with proposed structures in Berlin.

There has existed a very general popular opinion that underground electric railways would be accompanied with a greater degree of uniformity in temperature than existed on the surface, being cooler in summer, and not so cold in winter, this opinion being doubtless derived from the conditions existing in cellars and underground basements of buildings. Practical experience, however, showed the fallacy of this opinion, since, in the heated summer weather in New York it appeared that the temperature in the subway was from 3.3 to 4.4 degrees centigrade higher than that of the outside atmosphere, and that similar results were experienced in Paris.

This apparently unexpected result is simply explained by the fact that a large part of the electric energy delivered to the motors on the trains is converted into heat. Not only the losses in the conversion, but all of the energy suppressed in bringing the trains to rest, is converted into heat, and unless some method is introduced for its dissipation it not only appears as heat but the heat is allowed to accumulate until the temperature is raised to a degree too high for comfort. This is true not only of the electrical energy but of all the other forms of energy which are changed by the propulsion of trains through a tunnel against various resistances. Thus the rail friction, the atmospheric resistance, the brake friction, and every form of absorption of energy not otherwise accounted for must reappear as heat, and, in the absence of any special methods of dissipation can only, appear in the increased temperature of the contained mass of air.

The facts in such cases may be made to appear in a more concrete manner by the presentation of the subject in the way used by Inspector Kayser to give the natural result of the operative conditions. If, for example, the power house by which the electrical energy is furnished, consumes 500 tons of coal per day, and if only 10 per cent of this energy reappears as heat through unavoidable losses in the tunnel, the heating effect will be the same as that which would be produced by the combustion of 50 tons of coal per day in the tunnel, and devoted to the warming of the contained mass of air.

Inspector Kayser examines the computations which have appeared in some of the American technical journals regarding the actual amount of heat evolved in the New York subway, showing that this action is amply able to account for the difference in temperature between the air in the tunnel and that of the outside atmosphere, and he shows that the conditions in Paris confirm the results developed in New York.

Since the rate of dissipation of heat in a tunnel has an important bearing upon the rate at which the temperature of the contained air increases, Inspector Kayser considers that nature of the soil through which the tunnel passes as an element in the problem. The subway in New York passes through a body of sand and rock which forms a very effective non-conducting jacket to the tunnel, so that the conduction of heat through the walls is comparatively slight, and hence the only way in which the excess of heat can be effectively removed is by convection with the movement of the air. In this connection the experience with the underground portion of the Berlin municipal railway extending to Charlottenburg is cited, showing, in winter

weather, an increase of 4 to 5 degrees centigrade above that of the external air, while the surrounding earth showed a still higher temperature.

There appears to be no doubt that it is by a continual change of air that the heat is to be carried away from any such underground railway, and hence it should be a part of the original design of such a subway to provide for a determinate movement of the contained air by some artificial and controllable means.

Air which is intended to serve as a cooling medium should contain a proper amount of moisture, since this adds very greatly to its capacity for absorbing heat. Thus the evaporation of one cubic metre of water involves the absorption of 560,000 calories, an amount estimated equal to 10 per cent of the entire heat developed in the Berlin subway, and there appears to be no difficulty whatever in the evaporation of a cubic metre of water over a length of four kilometres. The absorption of such an amount of water need not render the air uncomfortably moist, since the movement of the air required for ventilation would effect a change with sufficient rapidity to keep the atmosphere from approaching such a degree of saturation to produce discomfort. When a tunnel is driven through moist earth it is advisable to permit this ground water to maintain the interior of the tunnel in a moist condition, this providing an absorbent for a large portion of the heat.

The movement of the air in tube tunnels is largely effected by the motion of the trains, the cars so nearly filling the section of the tubes as to act almost like pistons. For tunnels of larger section, admitting two or four tracks, this action cannot be relied on, and some auxiliary system should be employed. Where the tunnel is nearly level, probably the circulation of air will require the use of fans of other mechanical appliances, but if the road includes ascending and descending grades it will be found possible to place ventilating shafts at the highest and lowest points, the warm air ascending through the highest shafts will produce down currents through the shorter ones and thus maintain a circulation without the use of any machinery.

It is interesting to note in this connection that in the New York subway a plan is being installed which includes the mechanical exhaustion of air from points between the stations, while openings near the stations are made to provide for the inflow of fresh air, a very obvious improvement and one which might well be incorporated with any tunnel of later construction.

THE EDUCATION OF ENGINEERS.

REPORT OF THE SPECIAL COMMITTEE APPOINTED TO DISCUSS THE BEST METHOD OF PRACTICAL AND SCIENTIFIC TRAINING FOR ENGINEERS.

Institution of Civil Engineers.

FOR nearly three years there has been in session a committee of the Institution of Civil Engineers, including among its members some of the most eminent engineers in the United Kingdom, discussing the best methods of training for all classes of engineers, the scope of this inquiry including both scholastic and subsequent education. The instructions given to this committee stated that the principle that the education of an engineer should include both practical experience and scientific training, should be maintained. This committee has now made its report, and in view of the eminence of its members, and the length of time during which the subject has been under discussion, the report is certainly entitled to most respectful consideration. With a broad catholicity, which might well be imitated by professional organisations in other parts of the world, the Council of the Institution requested the cooperation of a number of other engineering societies, and the constitution of the committee includes representatives of practically all the co-ordinate branches of the profession. The scope of the work of the committee included preparatory education in preparatory schools; training in offices, workshops, factories, and on works; training in universities and higher technical institutions; and post-graduate work. A

vast amount of correspondence and preparatory work was carried on, and in this respect the committee appears to have been especially fortunate in receiving an unusually large proportion of replies to its inquiries.

So far as preparatory education is concerned, the recommendations of the committee appear to be almost revolutionary in their character. It is considered that the students should be taught something about English literature; that Greek should not be required, but that a colloquial knowledge of French and German should be acquired and that mathematics should be regarded as something more than an intellectual exercise! When to these remarkable attainments it is added that some knowledge of elementary chemistry and physics is considered, even if known under its ancient appellation of "natural philosophy," it will be realised that the committee has already been aroused and possibly that its efforts may succeed in awakening some other educators in the United Kingdom. The committee believes, and in this there are few, we imagine, who will differ from them, that students who enter technical institutions are ill-prepared, and that it is most important that the preparatory educational schools should do their work more intelligently, and thus relieve the technical schools from a heavy handicap. It does not seem to have occurred to the committee that this result would be attained simply by making the entrance conditions of the technical schools more rigid, and thus enable the same weeding-out process to be effected in Great Britain as has long ago been accomplished in other parts of the world.

There has naturally been attention given to the incubus of "established customs," and the report has had to be guided in many respects by the burden of methods inherited from earlier times. It does not seem to be realised that the profession of engineer is similar to the profession of lawyer, or physician, but rather that the engineer is what has been termed a sort of "sublimated tinker," and that, as such, he should be sent to the workshop for a year of two before he is allowed to enter the university, just to show him that he is nothing but a workman after all, and that by and by, if he is real good, he may be allowed to learn something more.

Great Britain has evidently something yet to learn from the nations with which she has to compete, and to realize that the highest kind of scientific training is none too good for the men who are to do the things which are necessary to maintain her supremacy in the conduct of the affairs of the world. In other lands young men are trained in the preparatory schools in such a manner as to render them fully eligible to enter the universities immediately in grades fully equal to those held by other professional courses. The universities regard them, socially and technically, as the peers of students in every other department, and upon the completion of their courses these graduates are snapped up by the greatest manufacturing establishments in the world, before they have even had time to receive their degrees.

With such precedents before them it certainly does seem as if the committee of the Institution of Civil Engineers and other engineering associations might have looked beyond the encircling seas and endeavored to meet the competition of other lands, or even of the colonies of their own imperial realm. The world moves, and methods of education suited to present-day needs must not be hampered with the mediæval precedents of educational institutions of the past. The student of today should have to ask favors of no one, he should be able to make his own way with the training which he acquired by his own hard work. Manufacturing establishments, instead of demanding premiums from him for the privilege of entrance into their sacred precincts, should offer him living wages from the start, and understand that they are conferring no favors, but receiving full value therefor. The old apprenticeship idea is based upon the theory that the man in the shop knows it all, and that, by attrition and hard knocks, the apprentice may ultimately absorb some of his wisdom, while, as a matter of fact, the old-time machinist is as often as not a venerable moss-back, knowing little and caring less about the real progress of the shop in which he works, and bent upon maintaining the obsolete ways which he himself learned from his fathers.

The whole tendency of modern workshop methods is to get rid of the hand worker as much as possible, to provide modern, scientifically trained experts to keep automatic machines in operation with ordinary laboring service to the greatest possible extent; the shape of tool, the form of cut, speed, time, and all the rest, having been predetermined independently of the man who attends the machine. The scientific engineer who spends time in the shop learning such details is almost certain to find the whole scheme altered before he has an opportunity of putting his shop experience into practice, and in any case he is more than likely to be the one himself to apply the principles which he has acquired to the improvement of the method in the shop. In the cabinet of curiosities of one of the engineering associations there is preserved a hand tool once used by an eminent engineer, still honored on both sides of the Atlantic as the dean of his profession. Whatever skill may have been attained in the use of this clumsy combination of wood and steel is also relegated to the limbo of the past, and so in like manner, only far more rapidly, must go the individual shop methods of the journeyman mechanic of today.

One of the real difficulties, and one which is not touched upon in the report of the committee, is the lack of real practical men among the instructors and professors by whom the student must be taught. Too often the professor himself has never really been outside of the class room, having become an instructor upon his own graduation, and thence risen to the professorial chair without ever having had a chance of seeing how things are actually done in the workshop outside.

Post-graduate work receives notice in the report of the committee, coupled with the statement that the number of post-graduate students is not likely to be large at any time. If the original educational work has been properly conducted the whole subsequent career of every student should constitute post-graduate work of the highest order, and it is by the results of this true post-graduate work that the merits of any system of education are to be judged.

In its closing paragraph the committee refers to the "sympathetic" assistance of employers as essential to improvement in engineering education and training. Any system which depends upon the "sympathetic assistance" of the employer is likely to wait a long time for help and encouragement. Mr. Andrew Carnegie tells of the time when his firm was induced to employ a German chemist who wore spectacles, and also relates how this same spectacled chemist soon showed them how they were wasting many thousands in their ignorance of the qualities of the materials which they were buying and selling. The "sympathetic employer" needs to be shown that it is money in his pocket to employ the technically trained student, and as soon as that fact is realised there will be no further need for plans for technical education to be formulated, the demand will create its own supply of properly trained men, and the employers themselves will endow the educational institutions in Great Britain as they have done in other lands.

THEORY AND PRACTICE IN MACHINE DESIGN.

APPLICATIONS OF THE PRINCIPLES OF THEORETICAL MECHANICS TO PRACTICAL MACHINE DESIGN.

H. Lorenz—Verein Deutscher Ingenieure.

IT is not so very long ago that the idea of the so-called opposition between theory and practice was generally accepted, and the practical man was held by the general observer to be the man who really did things, while the theoretical student was generally considered as a visionary and unpractical individual. That this view of things has been replaced by one which accepts the union of both theory and practice as especially valuable, is now well known, and indeed it is largely because of the acceptance of methods indicated by students of theory and its application to practical work that the great industries of the world have grown to their present enormous importance. In an address delivered recently before the *Verein*

Deutscher Ingenieure, and published in the *Zeitschrift* of the society. Professor Lorenz discusses the relation which the application of theoretical mechanical principles bears to the development of modern machine design, and cites some important results which have followed from the union of the two elements, formerly considered as nonrelated, if not antagonistic.

Dr. Lorenz calls attention to the important influence which the mechanical laboratory has had upon the application of scientific principles to practical work. During the past fifteen or twenty years, both in Europe and America, the mechanical laboratory has become an accepted part of the training material in the university and high school. The student has by this means had opportunity of seeing the meaning of many things which otherwise made but a faint or fleeting impression upon his mind. Mathematics, from being a training for the mind as a sort of intellectual gymnastics, became a working instrument, not greatly different from the tools in the shop, while the certainty that theoretical deductions were to be put to the stern test of actual trial brought with it an honesty of work and purpose not formerly attainable. The laboratory was therefore a means for the development of both the teacher and the pupil, and in the opinion of Dr. Lorenz, this phase of technical instruction has had much to do with the development of applied science.

One of the departments of theoretical mechanics which has had an important influence upon the development of applied science is that relating to the study of vibrations. This fertile field of scientific study relates to all phenomena which have a well defined periodicity, and which return upon themselves at regular intervals of time. One of the simplest examples of this form of motion is that of the swing, well-known to children, but hardly considered as an example of an important mechanical illustration. The pendulum, however, from the time of Galileo onward, has been a marked instance of the application of mathematics to mechanics, and since the time of Watt the circular pendulum has been the basis of nearly every form of speed regulator in practical use. Following the study of oscillations still further we reach the broad subject of alternating electrical currents, which play a most important part in the transformation and long-distance transmission of energy in the form of electricity, and which have enabled mathematical research to be applied in a wide sense to mechanical problems of a most practical nature.

The mathematical study of mechanical problems has enabled the engineer to solve some important questions relating to disturbing vibrations in machinery. Thus, the action of reciprocating masses in high-speed steam engines has been studied with excellent results. Dr. Lorenz gives much credit to Radinger for his complete analysis of this problem in his important work, published first in 1870 and recently in a newer edition, but it must not be forgotten that this whole question was entirely solved by Mr. Charles T. Porter in connection with the design of the Porter-Allen engine, which was exhibited in complete running condition at the Paris exposition of 1867. The principles of the proportion of reciprocating parts in high-speed machinery now constitute a definitely solved problem, and one which could only have been settled by the application of the principles of mechanical theory to an important department of machine design.

With the application of multiple-expansion engines to marine propulsion and with the increase in the dimension of steamships came the question of the balancing of the engines so as to avoid the vibration of the hulls which had been growing objectionable and even injurious. A study of the theory of vibrations showed that the hulls of large vessels had well-defined periods of vibration and that if suitable multiples or divisions of these rates of vibration were produced by the engines a cumulative effect might be produced which was at least unpleasant, and at most might be disastrous. By the application of the theory of vibrations to the conditions of operation the remedy became apparent, and today engines with multiple cranks have their crank angles so arranged that the various forces oppose each other in such a manner as to reduce vibration to a minimum, while the period of the propellers and the hull are so chosen as to render cumulative effects a minimum as well. Professor Lorenz natu-

rally desires to secure as much credit and honor to German engineers, as possible, and we are far from wishing to diminish any portion of the honor belonging to the profession in Germany for the application of theoretical principles to practical work. Herr Schlick deserves great credit for the important work which he has done in applying the correct principles of mechanical science to balancing of marine engines, and we are especially glad to perceive that Dr. Lorenz gives proper credit also to the American naval constructor, Mr. D. W. Taylor, for his pathmaking work in this same department of applied science.

This important question of oscillations extends into nearly every field of applied science. Dr. Lorenz shows how it affects the resistance of beams, the torsional resistance of shafting, and the whole scope of resistance of structural combinations in a way which can be studied only by the engineer who is familiar with the correct theory of mechanical action. Any so-called practical solution of such problems can be but empirical at best, and there is no way in which practical experience gained from one case can be extended to subsequent examples, while with the application of theory to actual examples general laws may be deduced for subsequent use in connection with similar work.

The use of the steam engine indicator is one of the oldest applications of scientific theory to actual practice, and this instrument itself has of late been subjected to scientific analysis, as its applications have become extended. The inertia of rapidly moving masses becomes an element of importance with high-speed motors, besides which questions of temperature and elasticity have to be considered.

In the domain of hydrodynamics the applications of theory to practice have become of increasing importance. Thus the laws governing the efflux of liquids from orifices have been made the subject of scientific investigation, while the contraction of the liquid vein has shown itself amenable to mathematical analysis. The increasing importance of turbine water wheels, in connection with the utilisation of natural sources of water power have led to scientific studies of the principles of such motors, with the result of increasing the practical efficiency of such machines.

Another department of applied science in which excellent results have been secured is that relating to the laws of friction.

The investigation of Lasche have shown the important influence which is exercised by temperature upon the coefficients of friction and the action of lubricants, while the researches of Stribeck have placed the subject of ball and roller bearings upon a scientific as well as a practical basis.

These are but a few of the instances which might be cited to show the close relation which now exists between theory and practice, and which demonstrate that the profession of engineering is rightly claimed to be the profession of applied science.

EXPLOSIONS IN MINES.

PRECAUTIONS AGAINST EXPLOSIONS OF DUST AND FIREDAMP IN THE CONDUCT OF AMERICAN COAL MINES.

J. T. Beard—Engineering and Mining Journal.

LAST month we reviewed in these pages a paper relating to the prevention of explosions in mines, based upon practice on the continent of Europe, showing what had been done and what might be accomplished to increase the safety of colliery workers. In a recent issue of the *Engineering and Mining Journal* there appears a paper by Mr. J. T. Beard, discussing similar conditions in the United States, this supplementing very acceptably the paper by M. Schmerber reviewed last month from the pages of *Le Génie Civil.*

"There is perhaps, at the present time, no subject relating to the protection of human life that demands the prompt, thoughtful and intelligent consideration that is daily being asked in behalf of mining. The importance of this great industry is acknowledged on every hand, but the increasing dangers of the work are not as generally comprehended or recognized. Even those most familiar with mining conditions often manifest a disinclination to regard those

conditions seriously, and every day the reckless miner is permitted to engage in practices known and admitted to incur great risks, from which all men would shink if contemplated in another atmosphere than that of the mine. This may be in part the result of ignorance, in many cases it is; but there is beside, a less responsible element in the make-up of the average mining man, an element for which there is no reasonable excuse, as there may be for some cases of ignorance."

After discussing the dangers which arise from falling roof and coal, Mr. Beard shows that while about 50 per cent of the accidents are due to this cause it is the other half, being those due to explosions of dust and gas, which can be made best subject to control and regulation. In this respect conditions in America are still behind those in Europe, and the new country has much to learn from the old.

"Mining in the United States, though not as old as in England and on the Continet, has still reached a stage where more coal is produced each year than in any other country. We cannot afford, therefore, to disregard longer the necessity that compels us, as other countries have done 25 years before, to do everything possible to safeguard an industry that measures the peace and prosperity of the country. No one can study the work and findings of the French Firedamp Commission, 1882; the Prussian Firedamp Commission, 1885; the Austrian Commission, the same year; the English Accidents in Mines Commission, 1886; and the Royal Coal Dust Commission of England, 1891, without being deeply impressed with the efforts these countries have made in this direction and the great good accomplished. Under our own Federal Government many of the States have acted on their own recognizance and appointed commissioners for the purpose of investigating local mining conditions relating to this class of accidents. Such were the Iowa Commission, 1902; and the Kansas Commission, 1905."

The earlier disasters in coal mines in all parts of the world were largely due to the ignition of gas by the open lights generally employed, and although the so-called "steel mill" of Spedding was devised as long ago as the early part of the eighteenth century, it was by no means as safe as was at first supposed, the inventor himself losing his life by an explosion of gas in his own colliery. It was not until the invention of the modern safety lamp in 1815, that it really became possible to employ a flame with any degree of safety in the presence of mine gases.

"A new era in the mining of coal at once began, but as great a boon as the safety lamp has ever proved to be, it could not wholly prevent the occurrence of explosions, which is chiefly due to the misuse of the lamp through ignorance on the part on the miner. Many miners today who use safeties betray ignorance or disregard or both, of their proper use. One of the first principles to be learned by one who is to use this lamp is that it is very unsafe when improperly used. One of the greatest evils in mining today and one which is probably responsible for many disasters and much loss of life is the official sanction of the use of mixed lights. If safety lamps are at all necessary in a mine chamber, they are liable to be required at the moment when the miner is most absorbed and least suspects his danger. One might as truly expect a child to escape unharmed if allowed to play with dynamite as to expect the ordinary miner to avoid accident when permitted to use an open light in a chamber or heading known to be generating gas. For the safety of men and the security of property this statement should be made even stronger: Where safeties are required in any section of a mine, an open light should not be allowed in that section, and if open lights are in use in other sections of the same mine, the roads leading to the affected district should be guarded by a responsible person to prevent any one entering the same with an open light. The point to be emphasized here is that mine regulation should absolutely prohibit the use of mixed lights, under any conditions whatever. This rule should be inexorable, and the penalty for its infringement should be severe. It is time that we arouse to the necessity of safeguarding this condition by some other means than leaving the question of the use of open lights to be determined indiscriminately by the judgment of the miner, or by the willingness of any official to allow a heedless

miner to assume risks that reason condemns."

After referring to the recent disaster at Courrières, Mr. Beard discusses the explosion which occurred at Fernie, in British Columbia, in 1902, and then proceeds to compare the effects of gas and dust explosions, showing that in the case of gas the force is concentrated at the initial point of ignition, while with dust the combustion advances, feeding on the intake air.

The force developed by an explosion is enormous. Mr. Beard computes, from the chemical reactions, the amount of heat liberated by the combustion of dust and of firedamp, showing that a pound of dust produces nearly 5,000 foot-tons by explosive combustion, while a pound of methane produces more than 9,000 foot-tons.

The meaning of these figures may be grasped better when it is understood that a pound of gunpowder develops about 500 foot-tons, and a pound of nitro-glycerine about 1,100 foot-tons.

"In considering a mine explosion there is a general willingness, not to say tenddency, to consider the gaseous condition of the workings in any given case as varying only with the physical conditions in the mine, by which is meant those conditions relating to the number of feeders active, extent of faults, area of abandoned workings, standing, frequency of roof falls, etc. Sufficient attention has not been given to the variation of pressure of gas that may occur at irregular intervals in the strata. This variation of pressure has its origin within the earth and results in a more or less spasmodic outflow or emisison of gas from the strata, which may be approximately called 'earth breath ngs.' The direct result of irregular earth breathings is a corresponding fluctuation in the gaseous condition of all underground workings. This theory if true, would give rise to periods of frequency of mine explosions, assuming an increased outflow of gas brings an increased liability of explosion. It is clear, however that explosions may occur at times when the outflow of gas is less, and may not occur in the proper periods when the outflow is stronger, but these would not necessarily argue against the theory of periods of danger. At the most such errant explosions would only prove that periods of danger in mines are not always periods of frequency of mine explosions."

CENTRAL-STATION ECONOMY.

THE INFLUENCE OF THE DEVELOPMENT OF THE DAY LOAD UPON THE ECONOMY OF CENTRAL ELECTRIC POWER STATIONS.

Iowa Electrical Association.

WHEN electricity was first introduced as a commercial undertaking the lighting business claimed first attention. This naturally meant a load which was practically nothing during the day time and which reached a maximum some time during the evening. With the development of electric power it appeared that it was possible to build up a day load which might supplement the electric lighting demands of the evening, and thus enable the plant to secure paying business during the twenty-four hours. This subject has been developed to a marked degree at the present time, and in the large cities there is ample demand for current for all purposes at all hours. In the smaller towns the day business has to be built up, and the desirability of doing this formed the subject of an interesting symposium at a recent convention of the Iowa Electrical Association. In discussing the subject Mr. C. H. Walsh, of Burlington, Iowa, gives an excellent presentation of the conditions under which such a plant must be operated.

"In the design of a central station plant, the one great aim is to attain the highest possible economy in the operation of all departments of that plant

"Boilers, engines, dynamos and distributing systems are so installed, that the maximum assumed load may be carried in an economical way. Economy means not only the saving of so much coal and water, but also the application of the energy derived from these requisites in such a way that the greatest money returns may be

obtained from them. Many plants, built originally, perhaps, for street-lighting purposes, or for commercial service from dark to daylight, have extended their scope of operations, adding other departments still, and increasing their revenue. The same is true of plants in the larger cities, where, although twenty-four hour service was given, the night lighting load was originally the principal source of revenue.

"The purpose of day load is, naturally, to be able to use apparatus installed to meet peak conditions, at times when the load curve approaches the minimum, making this curve come as nearly as possible to the straight line for the twenty-four hours, and making the machinery help pay fixed charges on the plant, at times where otherwise it would be idle. These fixed charges will naturally be increased to some extent by the addition of the necessary apparatus and means of distributing day load, and the extra labor necessary to handle it will need to be considered, still it is a fact that these items are but a small proportion, ordinarily, of the possible increase in revenue.

"Day load may be added in a variety of ways and each class of day service operates in a rather different way, in its effect on central station operation, as well as its economy.

"Central stations of the later day are generally so built that nearly all classes of electrical service may be furnished from the same source. This applies not only to electrical apparatus but as well to steam-driven machinery, whether turbines or reciprocating engines, and to boilers. All of this apparatus gives the best results at a certain load point, and the more nearly this condition is maintained the greater naturally will be the saving in coal and water, and the greater the returns in money. There are at this day some practical limitations to combined plants, but the efforts of manufacturers and designers will surely remove these in time."

It has been understood that the supply of current for the operation of electric railways offers an opportunity for lighting stations to add to their day load, but this is not as important a source of business as might be supposed. The load is very variable and the peaks of the railway load come very close to those produced by the demand for light, especially during the winter months, so that, unless storage batteries are installed, there is not much to be gained by the combination. It has generally been found preferable for railway stations to instal their own power houses, leaving the lighting stations to derive their day load from sources which interfere less with their normal night business.

"The usual method of adding day load is by the sale of commercial electric power for operating elevators, pumping plants, factories, small refrigerators, etc., and this class of day load is most profitable, being what is necessary for a central station heating plant, and in itself giving good returns at the station. It is the type of load most easily added to any plant, whether operating single of polyphase alternating or direct current. Many of the plants in the smaller towns still operate their single-phase equipment of former days, and are in good condition to use it to advantage in this day of improved single-phase motors. The single-phase motors now on the market, possess all the characteristics of the reliable direct-current series motors, combining great starting torque with low starting current, requiring less in transformer installation and cutting down transformer losses, which on polyphase systems with the necessary two or three transformers for each installation, are a considerable item of the idle load on the plant."

In discussing the subject, Mr. W. J. Greene compared the conditions existing today with those obtaining fifteen years ago.

"It must be remembered that this data is from operative conditions existing fifteen years ago. Advancement in the art of central station operation and management would enable any plant at this time to do much better, and taking these facts into consideration, I believe the above percentages are applicable and will give conservative results if used in estimating the effect of a day service on any plant. There are many uses to which electricity can now be applied that were not available fifteen years ago. Cities in which no gas plants are installed give unlimited possibilities for heating devices, a field that is

slow to open up in gas-covered cities. Look at this partial list of utensils, now a commercial commodity: flat-irons, curling-irons, cigar-lighters, hot-water urns, coffee-pots, waffle-irons, hot-plates and broilers, oyster-cookers and stewers, toasters, chafing dishes, cereal-cookers, water-boilers, baking and warming-ovens, heating pads, glue pots and soldering-irons. Then look at the special uses to which electricity can now be applied for power purposes that were not available fifteen years ago: alternating-current fan motors, sewing machine motors, bellows, automobile charging sets, etc.; and the effect of a day service in increasing light consumption must not be overlookel. Consumers will be secured as a result of continuous service that could not otherwise be had. As soon as a day circuit is established, a demand will be found for day lighting in basements, halls, closets, bank vaults and parts of stores. We find that stores use current more and more in the day time, as a result of the darkening of rooms by window decoration.

"Before any plant undertakes a day service, the economical equipment of the power-house and the distributive system, and rates should be carefully gone over. With suitable equipment the increase in coal burned per kilowatt-hour should be slight, because the coal used in banking and starting fires will go far toward taking care of the dead day load. If the plant is amply and economically equipped for the night run, very little extra investment would be required for day service, possibly an additional boiler in order to provide sufficient time for cleaning. If the plant equipment is not properly arranged for the night run it should be remodeled, but this cost could not properly be charged to a day service. The saving during the night should compensate for the cost of remodeling. Another important investment that should be made before undertaking day service is to install watt meters at switchboard and on all consumers. Here again is an equipment that should be had anyway, and is not chargeable to day service. Stations that are now selling entirely or largely without meters might find the inauguration of a day service a good reason for immediately changing all consumers to meters."

In the electric light business, as in the telephone service, it is most important that the whole subject should be carefully studied when the station is being planned. The demand for current for light and for power should be carefully investigated, together with the extent and direction of probable growth, and before all things it should be remembered that that plant is most profitable which is kept continuously at work. The overhead charges on the idle machine as well as on the idle man keep on all the time, and it should be the business of the commercial electrical engineer to see that the plant is busy every hour in the year, remembering that interest, depreciation, and taxes are never idle.

THE INSULATION OF ELECTRICAL CABLES.

STANDARDIZED RUBBER INSULATION FOR WIRES AND CABLES FOR USE WITH HIGH ELECTRICAL PRESSURE.

John Langan—American Institute of Electrical Engineers.

WITH the enormous development of the electrical industries there has come also corresponding demands for certain materials of construction involved in the production, transmission, and utilisation of electrical currents. There is no doubt that the consumption of copper has been greatly increased by reason of its use as wire, in the construction of electrical machinery, and what is true of the conductor is true also of the insulation. In a paper recently presented before the American Institute of Electrical Engineers by Mr. John Langan, the question of the use of rubber insulation is discussed, with especial emphasis upon the necessity of using precise and carefully framed specifications in order that material of proper quality shall be obtained.

"The effect of the tendency toward high electrical pressure is nowhere more severely felt than in the requirement for insulated wires and cables, for insulation practically controls this feature of electrical dis-

tribution. Electrical pressures can, to be sure, be increased to almost any extent, and electrical energy be transmitted to almost any distance; but to control its pathway, to regulate its course, to prevent waste, and maintain safety, this is the problem—the big underlying problem—of all electrical distributions of today. Five hundred volts and under are easily controlled; but pressures of 5,000, 10,000 or 20,000 volts introduce new problems, problems that were not even thought of in the days when 110 volts was considered standard practice.

"On the distributing and not the generating medium, then, depends the success of the present tendency in electrical distribution. A badly insulated wire or cable will imperil the success of any system. Not only must the insulation itself be perfect, it must also be properly tested, properly installed and properly protected. And curiously enough, engineers while examining carefully every other feature of a transmission system, will often pass lightly over the question of cables."

Mr. Langan examines the National Electric Code and the rules of the Board of Fire Underwriters, and shows that these are by no means sufficient to secure satisfactory and durable insulating mediums.

Even if the requirements of these rules were correct there is no authoritative body having the power to enforce them, and it is the opinion of Mr. Langan that the only way in which reliable work can be secured for the consulting electrical engineer is to use proper specifications, and then see that these are carefully carried out on the work under his inspection. The use of definite specifications to insure standardization, instead of depending solely upon a subsequent voltage test, is believed to be desirable, since there are insulating materials which stand a test when new but deteriorate rapidly in service. The use of oil insulation in high-tension switches and transformers is well known, and Mr. Langan calls attention to the manner in which this fact is used to prepare insulating material which may not be of permanent value.

"Certain mineral and vegetable oils will, therefore, stand extremely high pressures, and in this we have a clue and even a proof, why many obviously cheap insulating compounds stand very high potential tests, and yet will, in a short time, break down in actual service. The logic of this anomalous condition is, that when these communicated oils in the compound evaporate—as they will in a short time—the temporary and adventitious virtues they possess disappear also, and the insulation, deprived of this artificial support, quickly falls into disintegration and decay. This is the inevitable history of all such combinations. The situation is somewhat akin to a horse "doped" for a race, who shows a surprising turn of speed for a short distance and then suddenly collapses. From this it will be seen that a puncture test is, in itself, an uncertain proof of dielectric excellence.

"What is it then that constitutes good insulation, and how can we ascertain and know it? This is the all-important question. With this assured, everything else logically follows. The consensus of opinion, derived alike from theoretical and practical experience, is that rubber is the best of all insulating materials. There will, it is believed, be little dissent from this established conclusion. Its use today is practically universal. It has survived the vicissitudes of time and experience, has successfully refuted the claims of all alleged substitutes, and stands today the unrivaled and indisputable factor in transmission, without which electrical progress would be uncertain and precarious. We need not, therefore, resort to any detailed proof of rubber's right to insulating pre-eminence. Twenty years of practical experience justifies the wisdom of its use. In fact, it is the quantity and quality of the rubber in the compound that differentiates the grade and determines the price of every wire and cable on the market.

"But while rubber is the principal feature of good insulation, it is not the only feature. As a matter of fact, rubber in itself is valueless as an insulating medium. The reason for this is that in its native condition it absorbs a certain amount of moisture, and when exposed to the air readily oxidizes. These factors of disintegration naturally preclude its use as a distinct and separate constituent for insulating purposes. But in conjunction with other ingredients, and when allied with sulphur, and properly vulcanized, it becomes not only absolutely waterproof, but indeed,

under normal conditions, one might say, indestructible. From this it will be seen that there are two factors involved in good insulation. The fundamental thing is, of course, that the rubber be fine Para. But it does not matter how good the rubber is or how much of it is incorporated in the compound, if the vulcanization is not properly carried out, the insulation will be defective. In fact, it is hardly exaggerating things to say that the art, or the science, of rubber insulation resides chiefly in the proper understanding of vulcanization. This consists in the addition of a certain percentage of sulphur—generally about three per cent—to the rubber and then subjecting the association to a certain temperature for a certain duration of time. The result is vulcanized rubber. Vulcanization, then, is that more or less mysterious factor which gives the rubber longevity, durability and immunity from oxidation when exposed to atmospheric and other conditions. In short, it is what may be called "embalming" the rubber. Without it rubber is absolutely worthless for insulating purposes; with it, it becomes, under normal conditions, virtually indestructible."

Mr. Langan calls attention to the fact that there are two elements in a rubber insulation which determine its quality, one being the amount of fine Para rubber which it contains, and the other the percentage of extractive or resinous matter. The higher the percentage of resinous matter the lower the quality of the rubber, the life of the rubber being in inverse relation to the proportion of resinous matter.

The test for the physical quality of rubber consists in its ability to return to its original length after repeated stretching.

It has been the practice to consider the physical properties of rubber by the original strength, but Mr. Langan calls attention to the fact that the ultimate strength is deceptive, and that rubber which may have a high strength when new may also be poor stuff not long after. The vulcanizing affects the character of the material very materially. If over-vulcanized it will be hard and brittle, and if under-vulcanized, flabby and inert. The best test is that of recovery after stretch, and Mr. Langan maintains that a good sample should fully recover after being stretched to three-and-one-half times its original length, a test not unlike that also involving the elastic limit used for determining the real value of other materials of construction, especially the metals.

The specifications suggested by Mr. Langan are too long to be given here in full, but they include the requirement that the insulating material should contain not less than thirty per cent of fine Para rubber, and not more than five per cent of resinous matter, and contain no shoddy, reclaimed rubber, rubber substitutes, or the like. He also gives tables of the insulations tests to be applied for various thicknesses of wall, for various purposes.

Puncture tests naturally form a part of the question, and Mr. Langan treats these about the same as the general engineer considers ultimate rupture test of materials of construction; that is, as liable to reach the point of injury, without passing it, and thus leaving the material in condition to break down with a much lighter stress.

"It is obvious that a cable may be well made up of very poor material, or it may be imperfectly made up of the very best material. In the one case there is good workmanship with poor material, and in the other bad workmanship with good material. In the first case the cable is intrinsically poor and in the second it is intrinsically good, but imperfectly made up. This imperfection may be slight or considerable; it may be due to a piece of gravel or an air bubble in the compound. In a case like this nothing but a puncture test will discover the fault. But the test should be nominal, and there is no need of pushing it to the point of rupture. If there is any weakness or imperfection, 5,000, 10,000 or 15,000 volts depending on the thickness of the wall of insulation will discover it after one minute's application.

"It may be laid down as a safe, general rule that a puncture test should never exceed double the working pressure, but this is true only up to a certain limit, say, 15,000 volts working pressure. After 25,000 to 30,000 volts are reached the temperature increases so fast that it becomes increasingly destructive to the vitality and durability of the insulation.

"Much of the present tendency for high potential and breakdown tests is the result

of an altogether erroneous comparison with tests imposed on paper-insulated and similar cables, which must, of course, be lead-covered before any test can be made. Such tests are of necessity "dry tests," whereas rubber-covered cables, on the contrary, are soaked in water and tested before the tape, braid or lead is applied. For this reason it is hardly an exaggeration to say that double the potential imposed on a paper cable is no more exacting than half the amount applied to a rubber cable. To expect, then, on a rubber cable anything like the same strain that is ordinarily put on a paper cable would be, in effect, expecting rubber to stand double what paper stands.

"In saying this there is no intention whatever to institute comparisons between rubber and paper or detract in any way from the merited recognition accorded to paper for certain work. All that is intended is merely to point out the fallacy of comparing tests that, in their very nature, admit of no comparison."

ELECTRIC CRANES.

THE SUCCESSFUL USE OF THE ELECTRIC CRANE FOR HANDLING HEAVY WORK IN THE IRON FOUNDRY.

American Foundrymen's Association.

POWER cranes have been used in the foundry for a long time, and until electric power was sufficiently developed to be applied to such machines the flying rope and the square shaft were used for traveling cranes, while the hand-operated jib-crane still held its supremacy where smoothness of action and definite control were essential. The development of the electric crane was a natural result of the improvements in the general application of electric power to the driving of machinery during the past fifteen years, and at the present time nearly all travelling cranes in use, both in the machine shop and in the foundry are operated by electric motors.

In a paper presented by Mr. Harry Sawyer before the American Foundrymen's Association the especial applicability of the electric crane to foundry work is discussed, with some remarks which are applicable to cranes in general.

"It is no doubt true that the foundry has set the standard of excellence for electric cranes. Some shops and mills may have heavier loads to handle and require greater speed, but the crane manufacturer recognizes that the perfect control required in the foundry represents a higher state of development than mere requirements of capacity and speed. It should not be understood that good control is not required in mills and shops, particularly in the latter, but as a rule the requirements of the foundry are much more exacting.

"The conditions under which a foundry crane is operated are less favorable to continued good service than the conditions in a machine shop. It is more subject to overload, and the dirt and dust necessitate more careful attention. Furthermore, the men directly responsible are usually less familiar with machinery, with the result that the crane too often does not have the care it should. It it a mistake to assume that a crane which does the work of an army of laborers can safely be handled and cared for by one of that class. The importance of employing only thoroughly competent and conscientious operators and keeping the cranes in perfect repair cannot be too strongly urged. Prompt attention will reduce the total cost of repairs and the extra cost of careful and competent men will be saved many times by the more constant service and longer life of the crane."

One of the most important advantages which have resulted from the application of electric driving to cranes is the simplification of the mechanism. Those who are familiar with the machinery of the earlier types of rope of shaft-driven cranes will remember the complicated system of clutches and gearing by means of which the single continuous motion, delivered to the bridge from the line shafting, was converted into the three co-ordinate movements of bridge-travel, trolley-travel, and hoisting. The first electric cranes were made with but a single motor, so that the full advantages of the new power system

were not realised. It soon appeared, however, that the true solution of the problem was to use a separate motor for each separate function, and at once the whole mass of machinery fell away before the modern three-motor crane, in which a separate motor is used for the operation in each one of the three dimensions by which the entire space beneath is covered.

Mr. Sawyer discusses the present tendency toward excessive operative speeds, showing that the assumed gain in time is often neutralised by the natural limitations which are governed by the work.

"Two objections may be offered to excessively high speeds. First, the accidents that are likely to result from putting a high speed crane in the hands of an incompetent operator often cause the loss of much more time than is saved by the higher speeds, and greatly increase the cost of repairs. Second, if the crane is not usually run at full speed there is a constant loss of power in the rheostat, and the unnecessary wear and tear on the controller parts, both of which cause expense and loss of time. The above comparisons apply with the most force to cranes in mills, where much higher speeds are necessary and practical.

"Next to the requirement of necessary strength in all parts for absolute safety, the most important point to be considered is perfect control of the hoisting mechanism. This depends upon three parts: the motor brake, the load brake and the controller. The motor brake is released by the current which operates the motor, and should require only as much current as is necessary to drive the machinery without load. It should be sufficiently powerful to bring the armature to a stop promptly, but without shock, when the current is interrupted.

"The load brake is a far more important part. It must allow the machinery to run freely in hoisting, but prevent the load from descending, except when the motor is run in the lowering direction. In most if not all forms of load brakes now in use the brake is applied by the action of the load. They may be divided into two classes: one in which the brake pressure is not reduced in lowering, but the motor acts with the load to cause the brake to slip, and the other in which torsion of the motor in the lowering direction reduces the pressure between the surfaces, allowing the brake to slip and the load to descend. The most common of the first class is the enlarged step bearing on a worm shaft. It can be used only in connection with worm gearing. It is a very simple and may be made a very satisfactory working brake. The most serious objection to it is this: If proportioned to give a fair margin of safety with the best conditions of lubrication, it will take considerable power to lower with moderate or poor lubrication, for the motor must overcome any excess of holding power over that necessary to sustain the load. This extra work in lowering means loss of time and power and greater wear of parts.

"Of the second class there are the coil type and the disk type. Both have their advantages and disadvantages. The disk type is more substantial in construction, gives better distribution of pressure over the friction surfaces, and consequently a much lower unit pressure; and as the pressure is strictly in proportion to the load it gives higher speeds in lowering light loads. It has this disadvantage, that it is more sensitive to irregularities in lubrication.

"In the coil brake the pressure and wear are concentrated principally at one end. While the brake is applied by the action of the load, the pressure and resistance to slipping are not strictly in proportion to the load. The torsional effort of the motor to release the brake is dependent upon the proportions of the brake parts and not upon the load, hence the speed in lowering is approximately the same for all loads. Both types are used by reputable builders and both may be designed to give good results.

"A good controller is indispensable to a satisfactory crane. The essential parts of the controller are the resistances and the means for varying the amount of resistance in the circuit according to the speed and power required. The most common practice is to divide the resistance into sections, connect the sections together in series and connect each section to one of a series of corresponding contacts. A brush is arranged to pass over these contacts, cutting more or less of the resistance

into or out of the circuit. Various materials may be employed and details used to obtain the desired result, but certain conditions must be complied with if satisfactory results are to be secured."

The development of the modern power crane is but one example of the manner in which the laborious work which was formerly performed by human effort is being relegated to machines controlled by skilled operators. It is a well-known fact that the modern work-shop contains far fewer men in proportion to the output than was formerly the case, although the individual grade of the operatives may be of a higher class. There is no especial merit or dignity in brute labor, however much this may formerly have been assumed to be the case, and every mechanical appliance which replaces the effort of human muscle must be considered as making for the general elevation of the race by rendering it more than ever necessary for man to use his brains rather than his hands. The art of *directing* the great sources of power in Nature is the true province of the engineer, and that art accomplishes its end in just such degree as it is exerted for the "use and convenience of man," and not for his misuse and inconvenience.

REFUSE DESTRUCTORS.

THE ECONOMICAL DISPOSAL OF MUNICIPAL REFUSE BY FIRE AND THE UTILISATION OF THE RESULTANT BY-PRODUCTS.

Institution of Engineers and Shipbuilders in Scotland.

THE destruction of municipal refuse by fire is a very old question, but it has become a renewed subject for discussion since it has been found practicable to derive a fair return from the by-products and thus materially lessen the cost of the operation. In a paper presented recently before the Institution of Engineers and Shipbuilders in Scotland by Mr. H. Norman Leask the present status of the subject is discussed, and some abstract of this examination is here given.

Mr. Leask reviews rapidly the construction and operation of the earlier refuse destructors, and then proceeds to discuss the principles upon which the more improved modern types have been designed.

"The call for better sanitary measures on the Continent, and in fact all over the world, has given an impetus to the construction of furnaces by foreign makers, notably in Germany and Belgium. Lately a competition was held in Brussels, and no less than five new makers of destructors submitted schemes, four German and one Belgian. No doubt these furnaces are largely based on British practice, and it is also fairly certain that British engineers dealing with the question will have to regard German engineers as worthy rivals at no far distant date.

"The larger proportion of early destructor plants in England was operated by natural draught, and the rate of burning does not appear to have exceeded six tons per day of twenty-four hours on a grate area of about thirty square feet. About the year 1894 forced draught was first applied systematically to refuse furnaces, and a much higher burning capacity with higher temperatures were obtained.

"Anyone doubting the advantage of the ues of mechanical means for supplying the air for the support of combustion, cannot but be struck by the increase in the rate of burning and consequent higher temperatures obtained in the destructor field by this means. This rate of burning has now gone up, and 60 pounds per square foot of grate area per hour is quite common, and has even passed 85 pounds, temperatures have also risen from a mean of perhaps 800 degrees F. to a mean of nearly 2000 degrees F., in some cases rising higher than 3000 degrees F. Water evaporated per pound of refuse has also risen from *nil* to over 2½ pounds from and at 212 degrees F."

The constitution of refuse naturally varies in different localities, so that it is impracticable to determine upon any standard design of destructor, and the appliances should be modified, especially with respect to the proportion of air admitted, according to the nature of the material to be consumed.

"The destruction of refuse is nothing more or less than the combustion of poor fuel. The difficulties to be faced arises out of the abnormal quantity of mineral matter, the high percentage of moisture and the relatively small quantity of combustible matter contained in the fuel.

"The manner in which the problem has been solved may be divided into two distinct groups, as already stated the distinctive feature of the earlier one being the division of the furnace into a number of isolated chambers, generally called cells, the other making provision for a furnace chamber common to a number of grates. The author would submit as incontrovertible that the latter type has given the better results from the standpoint of high temperatures, more regular maintenance of the same, and more complete combustion with a constant higher evaporative efficiency.

"It is claimed for the isolated system that repairs can be carried out without affecting the operation of the adjacent furnaces; this, however, appears doubtful if the adjacent furnaces are in full work, as it is by no means uncommon to find the fire brick linings red hot at a depth of nine inches from the working furnace face, and almost impossible to bear one's hand on a wall eighteen inches thick. As the isolated system presents a larger perimeter of fire-brick work exposed to the adherence of clinker, the repairs are also likely to be more frequent. In some makes this is obviated to some extent by fixing cast iron boxes through which the air for the support of combustion is passed on its way to the ashpit. The cubic contents of fire-brick lining in a furnace of this type is no doubt somewhat greater than with the common combustion space type, and therefore more heat may be said to be stored, but this construction renders it more difficult to obtain a suitable outlet for the products of combustion, the passages being necessarily small, and if high temperatures obtained would rapidly become choked up and almost impossible to clean."

The question of drying or dessicating the material is discussed by Mr. Leask, with especial reference to the plan, sometimes adopted, of allowing the material to be dried out upon a hearth before it is fed into the furnace, utilising the radiant heat for this purpose. Mr. Leask prefers to dry the material by the passage of heat through it as it lies on a grating, and in this respect his experience agrees with that of one of the most successful engineers in the United States, Mr. A. W. Colwell, who employed several superposed grates composed of water-tubes, the down-draught principle being employed, and the material passing through one grate to the next as it became dried and partially consumed, until it was completely burned on the lowest grate. The distilled gases in such an arrangement pass through the successive beds of incandescent fuel, insuring complete and effective combustion.

"There are many ways of obtaining a high temperature in a furnace, and it may seem strange that the temperature can be too high in a furnace, but it is a fact. It may be so high that particles of dust carried into the settling chamber become molten and on solidification require a great deal of labour and force to remove them. One of the simplest means of obtaining a high temperature is to work a furnace with a plenum above the grate bars, that is, combustion under pressure. It is well known that the effect of pressure is to reduce the specific heat of air, and, consequently, when a pressure above that of the atmosphere is created in the furnace, the temperature will rise; as the pressure above the grate seldom equals from half an inch to one inch of water, the calculated rise in temperature resulting from such a process would not be much above 50 degrees F. The actual observed increase in temperature, however, is very much greater than this, and is, no doubt, due to the fact that an air supply approximating more closely to the requirements of the fuel enters the furnace, also the entrance of cold air through the doors is absent, and, consequently, the calorific value of the fuel is dissipated over a smaller quantity of air. This method, if adopted. however, has very serious inconveniences. *Firstly*, it is impossible to open any furnace door without allowing an outrush of the products of combustion, and, *secondly*, suitable doors for closing the furnace when in operation, would be difficult to manufacture and maintain. On the other hand, if there is a decided vacuum above the grate bars, on

opening a furnace door large quantities of cold air will enter, with a consequent fall in temperature. It will, therefore, be seen that there is some mean point to arrive at which requires nice designing, in order that the best results can be obtained. Other means, however, can be adopted to obtain a higher temperature."

Mr. Leask discusses the important question of the handling of the material in the light of evident experience, showing the difficulties which must be met in this department of the work.

"The most vexed question is that of the best means of feeding refuse fuel into a furnace. Now this fuel varies with the locality, with trades, and with seasons of the year, in fact it may be said to vary hourly, and will consist of such varied material as a load of vegetable matter or fruit, load of paper, straw or ashes, leather cuttings, oilcloth cuttings, rolls of oilcloth, mattresses, paper, tins, bottles, fish, slaughter-house offal, etc.

"Five years ago it was common to see expressed in specifications a desire to receive schemes for charging furnaces mechanically, and much money, time, and trouble has been spent in endeavouring to arrive at this desideratum. Up to date it has not been achieved with any marked degree of success, and it may be said, with a great deal of truth, that plants giving the greatest satisfaction are those in which no such mechanical means exist. The material could, of course, be treated primarily, disentegrated and reduced to a uniform size, and then fed into the furnace in a simple manner, the cost of such machinery, and the maintenance and labour attending the same, however, exceed that of charging the furnace by hand. The author has had the opportunity of inspecting such apparatus at work and of verifying these facts.

"It is not a difficult matter to devise a furnace into which large quanities of refuse can be tipped, it is, however, a grave question as to whether it is advisable to proceed in this manner or not, if whole cart loads of refuse are tipped into a furnace no opportunity of selecting and varying the proportion of the material is permitted, nor can it be claimed that the charging of a furnace with a ton of refuse at a time is a scientific way of obtaining good combustion, it must necessarily mean great fluctuations in temperature, and it is questionable whether any saving of labour results. Picture a load of market refuse being discharged into a furnace, and subsequently a load of paper and straw, then a load of ashes, then large quantities of shell fish and tins, can anyone say that such a proceeding can give good results for a very large plant connected to a common chamber, and where it is merely a question of getting rid of the refuse; there might be an excuse for such an arrangement, but under no other circumstances could such a proceeding be justified."

The by-product of a destructor plant is the heat produced, which can be delivered to an associated boiler installation, and employed for the generation of electrical current. Mr. Leask gives detailed reports of tests of a number of plants showing that it is entirely practicable to evaporate from 1.5 to 2 pounds of water from and at 212 degrees F. per pound of refuse destroyed.

EFFECTS OF FIRE ON BUILDING STONES.

EXPERIMENTAL TESTS UPON THE RESISTANCE OF BUILDING STONE TO THE ACTION OF HEAT, WATER AND MECHANICAL STRESSES.

W. R. Baldwin-Wiseman—Surveyors' Institution.

WITH the disastrous fires which have occurred during the past few years, culminating in the conflagration which followed the earthquake at San Francisco, it has become more and more evident that a better knowledge of the fire-resisting properties of materials of construction is essential. A most valuable contribution to the literature of the subject appears in a paper presented before the Surveyors' Institution by W. R. Baldwin-Wiseman, giving data and results of tests which he has made upon a variety of building stones, both as to their original resistance, the direct effects produced upon them by exposure to high temperatures,

and the ulterior effect of exposure to heat upon their subsequent strength.

The author of the paper shows how meagre the present stock of reliable information is upon the subject, and in his preliminary remarks gives some very sound views upon the matter.

"The temperature and destructiveness of any conflagration are so entirely dependent upon the plan of the building, the nature and disposition of the material used in its construction, the nature of its contents, the time, location and cause of the fire, and other incidents, as to preclude all possibility of reduction to any standard formula, and a study of the stresses which a building has to withstand during and after a severe conflagration is also so complex a problem as to be practically indeterminate if viewed as a whole; but if one resolves it into separate considerations of design and material, it is brought more within the bounds of solution, and the range of every-day practice in design.

"For this reason, I regard as practically valueless all experiments which involve the construction of, say, a model room, and its destruction by fire, when, in many cases, the building material of which it is composed is comparatively fresh, the wall and floor stresses are trivial, and the internal space is utterly inadequate for the generation of a really serious fire. Far more profitable experience would result from a careful inspection of all interiors after the extinction of a fire, for much information as to the temperature of the fire could be obtained by a careful examination of the condition, fused or otherwise, of the metallic fixtures. Thus, for instance, lead melts at 326° C., aluminium at 625° C., and brass at 1,000° C., so that if, on investigation, it was found that the two first-named had melted, and the last-named had not, one would know that the temperature in the places in which they were severally situated exceeded 625° C., did not exceed 1,000 ° C.; and by tabulating the records of the intensity and destructiveness of fires in various buildings of similar plan, structural arrangement and trade, one would create an almost invaluable record for reference."

The scope of the researches was limited to a number of British building stones, all of which are described in detail in the original paper, but the conclusions may be accepted as generally applicable to building stones of similar character in other parts of the world.

In brief, the following points were considered:—

First.—The transverse and crushing strength of stone;

(A) When thoroughly dried in the steam oven so as to expel all absorbed water held in the pores, but not the water of crystallisation;

(B) When thoroughly soaked in water;

(C) When subjected for various definite periods to constant temperatures ranging from 500° C. to 820 C., and either slow cooled in air or suddenly cooled by immersion in cold water, immediately upon removal from the furnace, the latter case being intended to somewhat imitate the conditions when a jet of water is directed upon a burning building.

Second.—The expansion of the stone with increase of temperature from 20° C. to 300° C., and the permanent alteration in dimension on subsequent cooling.

The tabular statement generally given about the fire-resistance and of depreciation in strength of stones after exposure to heat, is that of Dr. Cutting, in which, placed in a decreasing order the following relations are given:

1. Marble
2. Limestone
3. Sandstone
3. Granite
5. Conglomerate.

These relative resistances are given under the assumption that water is not applied. The accuracy of this table is by no means borne out by the researches under consideration, and indeed, the variations in the physical structure in various members of these classes preclude the possibility of any such generic grouping.

Broadly, the stones included in the present tests included six sandstones, nine limestones and calcareous freestones, and three of igneous origin. The test pieces were dressed to prisms one inch square and six inches long, except a few samples in which the cross section varied slightly, the length being the same. The dimensions were determined to 0.1 millimetre, and the

weights carefully taken this latter determination being for use in connection with the moisture absorption tests.

The strengths were determined by crushing tests and by transverse breaking tests, while the heat tests were made by placing the specimens in an electric-resistance furnace made of mica and asbestos, about which a coil of chemically pure platinum wire was wound. The temperature was determined by a Callendar-Griffiths thermometer, the whole apparatus being capable of producing and maintaining uniform temperatures from 500 degrees to 820 degrees C.

A similar furnace, equipped with measuring appliances, and using mercurial thermometers for the lower temperatures involved in making the expansion determinations, was also used, and the tests appear to have been conducted with great care and judgment.

"Considering first those experiments for the determination of the strength of the stone, there were several phenomena worth recording. Many of the Doulting, Portland, and Bradford test-pieces emitted a peculiar crackling noise during the first five minutes after insertion in and removal from the furnace; the York stone changed in colour form a straw yellow to a terra cotta red, due possibly to a chemical change in the composition of the iron oxide in the cementing material of the grains of the stone. The Diabase changed from a dark greenish black to a dirty yellowish green; the Monks Park, Portland, Hopton Wood, and Boxground stones became chalky in appearance and somewhat lighter in colour; the Hopton Wood stone became internally mauve-grey in colour, and developed brown stains here and there; the Bradford and Bath oolites lost their fresh crisp appearance, became more or less earthy, and developed irregular red stains round some of the larger grains.

"The Aspatria test-pieces, soon after their insertion in the furnace, gave off a dense smoky cloud, which soon after flashed and burnt steadily, with a smoky yellow flame for about a minute. By trituration of some of the crushed stone with alcohol and subsequent distillation of the alcohol, a viscous amber-coloured combustible oil was collected.

"Several stones, such as Doulting, disintegrated in the furnace or immediately after removal therefrom. Others such as Doulting or Daresbury disintegrated immediately on immersion in or removal from the water, and one Daresbury retained its form during cooling, and carried its own weight upon the supports, but broke when the stirrup, weighing only two pounds, was carefully placed upon it, and fell as a mass of incoherent sand to the floor.

"Some, such as Doulting, Carrara marble, the Red and, in a less degree, the Grey granite, the Bradford and Bath oolites, and the Daresbury sandstone, had but little cohesion, and crumbled to powder when touched, or when more or less coarsely rubbed with the hand.

"Several Carrara marbles warped upon cooling, arching slightly; others, such as Hopton Wood, Monks Park, and Boxground stones, retained a sharp arris but the sides caved in, and cracks more or less deep developed at right angles to the direction of greatest length of the test piece."

The results of the tests for deterioration of strength by exposure to heat gave information fully confirming the statement that no general classification is practicable. Thus the York stone, a fine grained millstone grit, composed of siliceous grains embedded in siliceous cement, showed an original crushing strength of 550 tons per square foot and a transverse resistance of 70 tons. After exposure to high temperature the resistance to crushing became only 36 per cent of the original, and the transverse strength 65 per cent. The Red Mansfield stone, a calcareous sandstone, had a much lower initial resistance, its crushing strength being 160 tons pere square foot, and the transverse resistance 40 tons, but after exposure to high heat, and slow cooling in air, the crushing strength was not diminished, while the transverse strength was 62 per cent of the original. When cooled with water the crushing and the transverse resistances were 87 per cent and 60 per cent respectively, of the originals. These are only samples of the various results obtained, and similar discrepancies appear among the calcareous freestones. The chalks were practically ruined by heat, there being no residual strength worth mentioning. Marbles varied materially in their

strength after heating, but showed more nearly the same depreciation for both crushing and transverse strength than some of the other stones. Granites appear to be most useless in resisting heat. A red granite, with initial crushing and transverse strengths of 350 tons and 90 tons per square foot respectively, depreciated to less than 10 per cent of its original resistance.

One of the best results was that given by a quartzite, or dense metamorphosed sandstone, belonging to the Permian formation, this having a crushing strength of 240 tons per square foot and a transverse resistance of 150 tons. After exposure to heat, whether cooled in air or with water, it retained 71 per cent of its compressive strength, and about 90 per cent of its transverse resistance.

The paper of Mr. Baldwin-Wiseman contains much valuable information regarding the expansion and swelling of stones under heat, as well as the effects of moisture, which we have not space here to discuss, but, apart from the detailed results for the various stones tested, we append his general conclusions, with regard to fire resistance and prevention in buildings.

The points of primary importance in determining the most efficient design for fire resistance are:

1. That the edifice should in no wise be flimsy.

2. That it should be constructed of stone possessing an uniform or fairly uniform co-efficient of expansion, and retaining a considerable strength after subjection to high temperatures.

3. That all combinations of different stones should be avoided as much as possible.

4. That combinations of stone and metal should be avoided, especially when the former rests directly upon the latter, even when the metal is entirely enshrouded in stone, for stone acts as a fairly good conductor or heat.

5. That stair wells and lift wells should open as little as possible on to the main building, and should preferably be enclosed and glazed with wired glass from basement to roof.

6. That floor areas should not be unduly large nor corridors unduly long.

MODERN TRAIN LIGHTING.

THE USE OF INCANDESCENT GAS MANTLES FOR THE ILLUMINATION OF RAILWAY PASSENGER CARRIAGES.

H. Gerdes—Glaser's Annalen.

THE subject of the lighting of railway carriages is a matter which has been studied by engineers for a long time, and the continual improvement which has been made bears witness to the success which has attended the application of scientific methods to the question. The early trains were lighted with candles, and we believe that this primitive method has not been entirely abandoned in some of the carriages of the lower grades on railways in eastern Europe. Oil lamps are still used to a large extent, and they have many advantages, especially that of entire independence from any external disturbance, besides moderate cost in operation. With the demands from passengers for better lighting there has been introduced the system of compressed gas-lighting. including the enriched gas, Pintsch gas, acetylene, and kindred systems, followed by electric lighting systems. Numerous methods of supplying electric light have been devised, involving the sole use of storage batteries, the employment of independent dynamos on the engine or in the baggage car, and the use of separate dynamos, driven from the axles of each car, all of these involving the use of some accumulator reserve for use during long stops, or while cars may be detached from the train.

Gas lighting still maintains its supremacy in the greater portion of trains in Europe and America, and with the efforts which are directed towards its improvement it will probably still continue to be employed, at least, until electric traction supersedes the steam locomotive for main-line service.

In a paper recently presented by Herr H. Gerdes before the German Society of Mechanical Engineers, the question of applying the incandescent gas mantle to the

lighting of railway carriages is discussed, and some designs are shown which lead to the belief that this efficient and economical method of illumination may be very useful for this purpose.

The use of a mantle composed of the oxides of certain metals of the earths for the purpose of converting the heat of a burning gas into light energy is now about twenty years old, and there is little or no doubt that this invention, due to Dr. Auer von Welsbach, has been the means of enabling gas lighting to compete successfully with electric lighting. The fragility of such mantles, however, has generally caused it to be supposed that this form of light was unsuited for situations in which there was much vibration, such as on bridges and similar locations, and especially in railway trains. Later experiments have shown, however that this opinion was not altogether correct, and with the improvements in the manufacture of the mantles, and with especial designs for suspension, it has been found possible to use such burners on trains to marked advantage.

The earlier experiments with incandescent mantles in railway carriages were made in Germany, using several mantles of the ordinary form within a single glass lantern. This form involves the employment of a metallic support beneath the mantle, with its accompanying shadow, and hence the later installations have been made with the inverted burner, the mantle being of the spherical form, and the gas supply delivered from above. Herr Gerdes gives a number of illustrations, showing the detailed arrangements of such burners, as used on the railways of France, Germany, and Austria, as well as in England and gives a list of more than 3,500 cars which have been thus equipped.

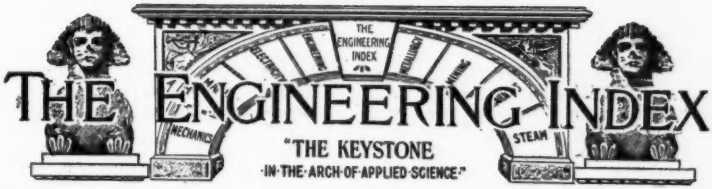
The only competitor of the incandescent gas burner for train lighting is the electric light, and here the operative cost is distinctly against the electric system, besides the necessity for providing storage battery or other reserve when the cars are at rest or separated from the locomotive. There is no doubt that the incandescent light is satisfactory to the passengers, while photometric measurements show that a greatly increased degree of illumination is given at a far lower cost than with either electricity of with ordinary gas burners, using Pintsch gas or gas enriched with acetylene.

The principal points to be provided for with the incandescent gas light are the method of lighting, the easy replacement of the mantle in case of failure, and the proper air supply and control of illumination. These points appear to have been fully met in the burners now in use in France and Germany, and there appears to be no reason why such high grade illumination may not be supplied on all railway trains at a lower cost to the companies than the inferior lighting obtainable from other sources.

The demand for better train lighting in Germany, especially for the first-class corridor trains, has been such as to cause the introduction of auxiliary electric reading lamps, while retaining the gas installation for the general illumination. It has also been thought necessary to retain the gas-lighting because of the liability to interruption of the electric current. The expense of this double system is naturally much greater than the employment of gas alone, and effort has been made to devise a lighting system which should utilise the existing equipment and give better results.

This appears to have been found in the inverted incandescent gas burner, to which the piping and gas storage tanks already on the cars are readily applicable. The pressure required for the inverted burner is somewhat higher than that used for ordinary gas burners, the best results being attained with a pressure of about 150 millimetres of water. The consumption of gas, however, is decidedly lower, since a Hefner candle is obtained from 1 litre of common illuminating gas, while with the ordinary burner 3 litres are required for enriched gas, or 2.5 litres for undiluted oil gas.

A point to be taken into account is that, with the incandescent burner it is the heating value of the gas which is desired, and hence it is not practicable to use the burner for oil gas, enriched gas, or common lighting gas indifferently, and it is desirable to have the incandescent burner adjusted for the quality of gas provided, and then maintain this standard as uniform as practicable.



The following pages form a **descriptive** index to the important articles of permanent value published currently in about two hundred of the leading engineering journals of the world—in English, French, German, Dutch, Italian, and Spanish, together with the published transactions of important engineering societies in the principal countries. It will be observed that each index note gives the following essential information about every publication:

(1) The title of each article,
(2) The name of its author,
(3) A descriptive abstract,
(4) Its length in words,
(5) Where published,
(6) When published,

(7) *We supply the articles themselves, if desired.*

The Index is conveniently classified into the larger divisions of engineering science, to the end that the busy engineer, superintendent or works manager may quickly turn to what concerns himself and his special branches of work. By this means it is possible within a few minutes' time each month to learn promptly of every important article, published anywhere in the world, upon the subjects claiming one's special interest.

The full text of every article referred to in the Index, together with all illustrations, can usually be supplied by us. See the "Explanatory Note" at the end, where also the full titles of the principal journals indexed are given.

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CIVIL ENGINEERING

BRIDGES.

Arch.

The Pennypack Creek Concrete Arch Bridge, P. & R. Ry. Illustrates and describes the construction of a bridge of five semi-circular arches, each of 60 ft. clear span, with an elevation of 80 ft. above low water. 1500 w. Ry & Engng Rev—May 19, 1906. No. 76715.

Three-Hinged Concrete Arch Bridge, Brookside Park, Cleveland, O. H. F. Hackedorn. Illustrates and describes the first three-hinged concrete arch bridge constructed in the United States, which is also the flattest semi-elliptical arch ever constructed. 1300 w. Eng News—May 10, 1906. No. 76616.

Austria.

Austrian Railway Ministerial Order of 28 August, 1904, Concerning Railway Bridges, Over-Bridges, and Approach Road-Bridges, with Iron or Wood Superstructures. Tables. 14000 w. Bul Int Ry Cong—April, 1906. No. 76953 E.

We supply copies of these articles. See page 637.

Bascule.

A Page Bascule Bridge at San Francisco, Cal. Illustrated description of a drawbridge of the trunnion type, with two leaves. 1500 w. Eng News—May 17, 1906. No. 76680.

Havre-de-Grace.

The Pennsylvania Railroad Bridge at Havre-de-Grace, Md. Illustrated description of a steel bridge under construction across the Susquehanna River, which represents the most advanced methods. 3000 w. Eng Rec—April 28, 1906. No. 76414.

Maintenance.

The Strengthening and Maintenance of Early Iron Bridges. William Marriott. From Proceedings of the Inst. of Civ. Engrs., with discussion and correspondence. Considers especially the West Lynn bridge over the River Ouse, and the Potter Heigham bridge, over the River Thurne. Tables and Ills. 17000 w. Bul Int Ry Cong—April, 1906. No. 76952 E.

Memorial.

The Hendrick Hudson Memorial Bridge. Illustration and information of a proposed bridge to span the Harlem River where it connects with the Hudson, to be built in commemoration of the tercentennial of the discovery of the Hudson River. 1200 w. Sci Am—May 5, 1906. No. 76498.

Reinforced Concrete.

A "Double-Drum" Reinforced Concrete Arch Highway Bridge. Daniel B. Luten. An unusual design at Muncie, Ind., is illustrated and described. 1200 w. Eng News—May 3, 1906. No. 76477.

A Reinforced Concrete Girder Highway Bridge of 40 Ft. Span. Daniel B. Luten. Illustrates and describes a new bridge built on abutments considered sufficiently good, which had formerly supported a wooden truss. 2000 w. Eng News—May 10, 1906. No. 76620.

Reinforced Concrete Highway Bridges on the Big Four. Illustrates two interesting designs in Illinois, describing details. 500 w. R R Gaz—May 18, 1906. No. 76745.

Reinforced Concrete Trestlework Viaduct for a Spanish Mineral Railway. Brief description, with illustrations, of two trestlework viaducts near Seville, Spain, and also of an ore-loading pier. 600 w. Eng News—May 17, 1906. No. 76675.

Short Span Concrete Bridges on the Long Island Railroad. Reinforced-concrete structures designed to carry the heaviest trains and locomotives at high speed are described. Ills. 1200 w. Eng Rec—May 19, 1906. No. 76739.

Rhine.

New Bridge at Basle. An illustrated description of the fine stone bridge over the Rhine, recently completed, and the methods of construction. 1700 w. Engr, Lond—April 20, 1906. No. 76451 A.

Viaduct.

Replacing the Ashtabula Viaduct. Describes the old structure and the new one made necessary by the increase in traffic and in weight of locomotives. Ills. 3500 w. Eng Rec—May 19, 1906. No. 76732.

CONSTRUCTION.

Building Details.

Dome and Floor Construction in the United States War College. Briefly describes this fine building in Washington, D. C., which is interesting on account of the very small amount of steel required for a structure of its size and containing so many wide spans. Arch ribs of the Guastavino type were used. Ills. 1500 w. Eng Rec—May 5, 1906. No. 76527.

Caissons.

The Use of Caissons in Bridge Building with Remarks Upon Compressed Air Illness. Thomas Oliver. Principally a discussion of caisson disease, its prevention, symptoms, treatment, etc. Discussion. 10000 w. Jour Soc of Arts—May 11, 1906. No. 76711 A.

Coffer Dams.

Economy of Steel Sheet Piling for Coffer Dams for Bridge Piers. Julian Griggs. A previous account of the construction of a bridge near Chillicothe, Ohio, using steel sheet piles for coffer dams has been given, and the cost is compared with the old coffer dam constructed on the same site in 1885, by the writer. 1300 w. Eng Rec—May 5, 1906. No. 76522.

Custom House.

Some Structural Features of the New Custom House at New York. Outline description of the building, illustrating details of interest, and describing special features. 2500 w. Eng Rec—May 19, 1906. No. 76736.

Dam.

The Pedlar River Concrete Block Dam, Lynchburg Waterworks. Illustrated detailed description of the construction of this dam in Virginia. 2800 w. Eng Rec—May 12, 1906. No. 76646.

Fireproofing.

Fireproofing and Insurance. Edward T. Cairns. A discussion of the position concrete is to occupy in the art of fireproof construction. 4200 w. Munic Engng—May, 1906. No. 76910 C.

Fireproof Domes and Stairways. George E. Walsh. An illustrated article showing examples of the use of terra cotta hollow tiles in the construction of ceilings, domes and stairways. 2700 w. Ins Engng—April, 1906. No. 76485 C.

Notes on the Fireproofing in San Francisco Buildings After the Fire. B. B. Hol-

land. An illustrated report of a number of buildings of fireproof construction, examined by the writer. 2000 w. Eng Rec—May 26, 1906. No. 76957.

Floors.

The Economical Design of Reinforced Concrete Floor Systems for Fire-Resisting Structures. Discussion of paper on this subject by John S. Sewell. 12000 w. Pro Am Soc of Civ Engrs—May, 1906. No. 76934 E.

Foundations.

The Steel Foundations of the Title Guarantee & Trust Co. Building, New York. Describes details of foundation work fr a steel-cage office building in New York City, especially the methods adopted for excavating below the water level. 1400 w. Eng Rec—April 28, 1906. No. 76415.

Framing.

A Study of Statically Indeterminate Frameworks (Studie über das Statisch Unbestimmte Raumfachwerk). Josef v. Gerstenbrandt. Discussing especially the framing of polygonal cupolas and similar structures, with analytical and graphical solutions, for various loadings. 6000 w. Oesterr Wochenschr f d Oeffent Baudienst—April 28, 1906. No. 76836 D.

Hotel.

The Hotel Blenheim. J. Fletcher Street. Handsomely illustrated descripton of a new type of construction used for a fine hotel at Atlantic City, N. J. It is an armored concrete and tile construction, and was built in six months, at a cost of $126,000. 2200 w. Brickbuilder —April, 1906. No. 76506 D.

Piers.

Novel Steel Pier Construction at Lome, Africa. Brief illustrated description. 400 w. Eng News—May 24, 1906. No. 76782.

Piles.

Manufacture and Use of Concrete Piles. Henry Longcope. Read before the Cement Users Assn. Reviews briefly the attempts with piles other than wood, and the development of this satisfactory system of construction now in use. 2300 w. Sci Am Sup—May 12, 1906. No. 76632.

Reinforced Concrete.

Economies in the Use of Reinforced Concrete. E. P. Goodrich. Discusses various methods of reducing cost; a solution of the centering problem; and the use of under steels and adaptability of the molds. Ills. 2500 w. Cement Age —May, 1906. Serial. 1st part. No. 76517.

Suggested Plans for Reinforced Concrete Earthquake-Resisting Fireproof Building Construction. Editorial discussion of the behavior of this material in the recent California earthquake and fire, and its use for building construction, with a letter from John Hawkesworth. 3000 w. Eng News—May 24, 1906. No. 76784.

The Advantages and Limitations of Reinforced Concrete. Summary of a paper by Charles S. Hill read before the Portland Cement Mfrs., reviewing the merits and defects of this material. 1000 w. Sci Am—May 12, 1906. No. 76626.

The Rational Proportioning of Structures in Ferro-Concrete. Gives a note concerning methods of verifying the dimensions proposed for armored concrete works on the Coignet system, which may also be applied to other systems. 1500 w. Engng—May 4, 1906. No. 76670 A.

Typical Systems of Reinforced Concrete Construction. Remarks on the adaptability and economy of this material, with illustrated descriptions of typical systems of construction. 4000 w. Sci Am—May 12, 1906. No. 76627.

Retaining Wall.

Difficult Reinforced Concrete Retaining Wall Construction on the Great Northern Railway. C. F. Graff. Illustrates and describes the methods pursued in building the retaining wall and fill at Bridge 123, which is 25 miles west of Summit, Montana. 5700 w. Eng News —May 3, 1906. No. 76472.

Roads.

The Drainage of Earth Roads. Abstract of a Bulletin by Prof. Ira O. Baker, published by the University of Illinois. Considers tile drainage, side ditches, surface drainage, and maintenance. 4500 w. Eng Rec—May 5, 1906. No. 76525.

Roofs.

For Good Tin Roofing. W. B. Goddard. A discussion of the kind of material, preparation, application and finishing, with comments. 3000 w. Met Work—May 12, 1906. No. 76594.

Moving and Raising an Old Wood and Iron Roof. Describes an interesting piece of work in connection with alterations at the Riding Club, 59th St., New York City. Ills. 1000 w. Eng Rec—April 28, 1906. No. 76418.

San Francisco.

Comments of Californian Engineers on the Earthquake and Fire. Edward M. Boggs. Notes on the destruction, and damage, with illustrations showing effects. 3200 w. Eng Rec—May 5, 1906. No. 76523.

Comments of Californian Engineers on the Earthquake and Fire. An account of the earthquake, by Prof. Frank Soulé, with short notes from a number of writers. Ills. 2800 w. Eng Rec—May 12, 1906. Serial. Part I. No. 76648.

Effects of the Earthquake and Fire Upon the City of San Francisco and Its Buildings. Brief illustrated account. 1200

We supply copies of these articles. See page 637.

w. Sci Am—Mav 19, 1906. No. 76688.

Injuries by Earthquake to the Buildings of Stanford University. Gives an official statement, with illustrations, showing the damage to these buildings. 1500 w. Eng News—May 10, 1906. No. 76617.

Notes on the Californian Earthquake. Reports from Carl Leonardt, by the State Board of Architects, and by the Home Fire Insurance Co. Ills. 2000 w. Eng Rec—May 19, 1906. No. 76733.

San Francisco in Ruins. General views and maps with an account of the devastation wrought by earthquake and fire. 8000 w. Ins Engng—May, 1906. No. 76795 C.

Some Effects of the San Francisco Earthquake on Water-Works, Streets, Sewers, Car Tracks and Buildings. Charles Derleth, Jr. An illustrated article showing the damage wrought, with explanation of the fault line along which the worst effects are found. 5800 w. Eng News—May 17, 1906. No. 76683.

Some Lessons from the Earthquake. S. B. Christy. Discusses principally the ruin due to the fire, and how much of it could have been avoided; offering suggestions for the rebuilding of the city on a safer and improved plan. 2000 w. Min & Sci Pr—April 28, 1906. No. 76637.

Some Views and Lessons of the San Francisco Disaster. An illustrated article showing the effects of earthquake and fire, and discussing the construction work that best stood the test. 2000 w. Sci Am—May 12, 1906. No. 76631.

The California Earthquake: Movements Along the Santa Cruz Fault Line. John C. Branner. Explains the geology of the region, showing that the earthquake disturbance was due to the geological structure. 700 w. Eng News—May 17, 1906. No. 76682.

The Cause and Nature of Earthquakes. G. K. Gilbert. Remarks on the origin of earthquakes and the nature of the vibrations. 800 w. Min & Sci Pr—April 28, 1906. No. 76636.

The Earthquake at San Francisco. W. G. Mitchell. An interesting account of the damage as viewed by the writer. 3000 w. Am Archt—May 19, 1906. No. 76712.

The Effect of the California Earthquake on Reinforced Concrete. John B. Leonard. Illustrations of buildings, with facts concerning them, showing the reliability of this material. 2000 w. Eng Rec—May 26, 1906. No. 76956.

The Effect of the Earthquake at Stanford University, Cal. Prof. Charles D. Marx. Gives the report of the examining committee on the condition of the buildings. Ills. 1200 w. Eng Rec—May 12, 1906. No. 76647.

The Recent Earthquake in Central California and the Resulting Fire in San Francisco. J. D. Galloway. An illustrated account of the damage wrought, and the effect on different classes of structures. 2000 w. Eng News—May 10, 1906. No. 76622.

The Saving of the Western Electric Building at San Francisco. Describes the construction of this building which withstood the recent earthquake and fire with very little damage. 1800 w. Eng Rec—May 12, 1906. No. 76649.

Tunnels.

Construction of the Gallitzin Tunnel on the Pennsylvania Railroad. Illustrated detailed description of the construction of this new tunnel for west bound trains. 2400 w. Eng Rec—May 5, 1906. No. 76526.

Recent Tunnel Construction of the Rapid Transit Railroad in Brooklyn. Illustrated description of the section from Court to Clinton St., where the subgrade was from 33 to 52 feet below the surface, and the conditions difficult. 4500 w. Eng Rec—May 12, 1906. No. 76650.

Relining the Allegheny Tunnel, Pennsylvania R. R. Illustrates and describes extensive repairs and the method of carrying them out. 1300 w. Eng Rec—May 12, 1906. No. 76651.

Troubles with East River Tunnels. S. D. V. Burr. Describes the troubles from blowouts, and from distortion in the tubes being placed under the East River at New York, and the methods of overcoming the difficulties. 1200 w. Ir Age—May 24, 1906. No. 76770.

Underpinning.

Underpinning the Marshall Field Building in Chicago. An interesting illustrated description of method of shoring a building while heavy foundations were constructed under it, and under very difficult conditions. 4000 w. Eng Rec—May 5, 1906. No. 76520.

MATERIALS OF CONSTRUCTION.

Asphalt.

The Uses of Natural Asphalt in the Arts. Felix Lindenberg. A brief review of past uses, with a description of some of the more important present uses of natural asphalt. 5000 w. Sci Am Sup—May 5, 1906. No. 76502.

Cement.

A New Magnesium Oxy-Chloride Cementing Material. Thomas W. Capposi. Information concerning this material and its uses. 1100 w. Eng News—May 17, 1906. No. 76676.

British Standard Specification for Cement. The comments of an English engineer on the work and report of the

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committee which drew up the British Standard Specification for cement. 1000 w. Cement Age—May, 1906. No. 76518.

Problems in Burning Portland Cement with Long Rotary Kilns. Carleton Ellis. A discussion of the "long" kiln and its economies, with remarks on the Eldred system. Ills. 1000 w. Eng News—May 24, 1906. No. 76781.

Clay.

Burnt Clay as the Universal Building Material. F. W. Fitzpatrick. Historical review of the use of this material, urging its value as a fireproof material. Ills. 4000 w. Brick—May, 1906. No. 76585.

Concrete.

Concrete Mixing Machinery. Illustrates and describes a number of interesting concrete mixers of various types. 2500 w. Sci Am—May 12, 1906. No. 76629.

Concrete Mixing Machinery. William L. Larkin. General discussion of machinery for concrete mixing, the defects of the earlier machines, and the types in use at present, and the method of operating. 5000 w. Sci Am Sup—May 26, 1906. No. 76791.

Determining Quantities in Concrete Mixing. Sanford E. Thompson. Presents an average and uniform method for proportioning materials for Portland cement concrete. 900 w. Cement Age—May, 1906. No. 76519.

Concrete Blocks.

Cement Block Architecture. Louis H. Gibson. Gives illustrations of successful work with this material, discussing them and the material used. 2500 w. Munic Engng—May, 1906. No. 76909 C.

Concrete Block Machines. Illustrates and describes types, with remarks on the material and its advantages in fireproof construction. 1800 w. Sci Am—May, 1906. No. 76630.

Corrosion.

The Preservation of Iron and Steel. B. H. Thwaite. Considers the effects of corrosion and discusses methods of preservation. 2000 w. Ir & St Mag—May, 1906. No. 76900 D.

Dynamite.

Proper Methods for Thawing Dynamite. Information from a brochure printed by the DuPont Co., Wilmington, Del. 1100 w. Eng & Min Jour—May 12, 1906. No. 76606.

Plaster.

I. Plaster-Work. George P. Bankart. II. Decorative Plaster Ceilings. Laurence A. Turner. Two papers discussed together. Traces the development of ornamentation in plaster work in the first paper; and deals with the materials used and execution of the work in the second. Ills. 9300 w. Jour Roy Inst of Brit Archts—April 28, 1906. No. 76713 B.

Rigidity.

The Rigidity of Constructive Materials. James E. Howard. Gives diagram showing the moduli of elasticity of different engineering materials, with notes. 1200 w. Eng Rec—May 26, 1906. No. 76960.

Rock.

The Rationale of Rock Crushing. O. H. Howarth. Explains the conditions under which a rock breaks when crushed by a stamp, crusher, or rolls. 4500 w. Mines & Min—May, 1906. No. 76510 C.

Stone.

Manufactured Stone. Charles D. Watson. A review of the progress of cement work in Canada, with an estimate of the value of manufactured stone in its relation to reinforced concrete construction. Ills. 2800 w. Cement Age—May, 1906. No. 76516.

Tension.

Some Tests Bearing on the Design of Tension Members. Edward Godfrey. States a clause in specifications for steelwork and reports tests made of the principle implied, discussing some other things brought out by the investigation. 2200 w. Eng News—May 3, 1906. No. 76473.

Timber Preservation.

New Tie and Timber Preserving Plant of the Atchison, Topeka and Santa Fe Ry. at Somerville, Texas. Describes the creosoting process used, the seasoning, inspecting and marking, the plant, machinery, equipment, etc. Ills. 4500 w. Eng News—May 3, 1906. No. 76474.

MEASUREMENT.

Alignment.

Co-ordinate Geometry Applied to Problems in Railroad Alignment. G. L. Bilderbeck. Reviews some of the fundamental principles showing their application to railroad work. 2000 w. Eng Rec—May 26, 1906. No. 76958.

Leveling.

Experience with the Prism Level on the United States Geological Survey. E. M. Douglas. Illustrates and describes this instrument, giving information of its working and cost. 2000 w. Eng News—May 17, 1906. No. 76678.

The Cséti Mine Leveling Instrument as Modified by Dolezal (Das Gruben-Nivellierinstrument von Cséti und seine Modifikation nach Prof. Dolezal). E. Dolezal. The improvements include the method of supporting the telescope, the graduation of the rod, and details of adjustment. The use of the instrument in the mine is shown. Serial. Part I. 3000 w. Oesterr Zeitschr f Berg u Hüttenwesen—April 28, 1906. No. 76828 D.

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Maps.

The Use of Freehand Sketching in Preparing a Topographical Map. Prof. Arthur Lakes. Considers what should be shown and the manner of indicating it. Ills. 2500 w. Mines & Min—May, 1906. No. 76514 C.

MUNICIPAL.

Conduits.

Conduit Construction Through Saw Mill Refuse. Illustrated description of unusual conduit construction at the Parke-Davis works in Detroit, Mich. A water pipe, outfall sewer and pipe conduit were all laid in the same trench. 1300 w. Eng Rec—May 5, 1906. No. 76528.

Destructors.

Refuse Destructor Combined with Electric Light Plant at Westmount, P. Q. Describes and illustrates a plant for a town of about 12,000 inhabitants, near Montreal. Gives a test of the destructor and boiler. 3000 w. Eng News—May 24, 1906. No. 76785.

Refuse Destructors. H. Norman Leask. Briefly reviews the history and evolution of types of furnaces, discussing technical points, and reporting tests. 9000 w. Ills. Trans of Inst of Engrs & Shipbldrs in Scotland—March 20, 1906. No. 76696 D.

Sewage.

A German Sewage Disposal Plant. William H. Schladitz. Describes the works at Naumburg on Saale. Also water purification. Ills. 1500 w. Munic Jour & Engr—May 2, 1906. No. 76491 C.

Biological Methods of Sewage Disposal for Farm Houses, Country Estates and Summer Resorts. William Paul Gerhard. An explanation of the principles of the bacterial methods, illustrating their practical application by examples. 5200 w. Met Work—May 5, 1906. No. 76496.

Pasadena Sewer Farm. S. F. Pearson. An illustrated account of a very satisfactory method of sewage disposal, stating some of the obstacles encountered and the success attained. 2000 w. Munic Jour & Engr—May 2, 1906. No. 76489 C.

Sewage Purification for Columbus, Ohio. George A. Johnson. Explains local conditions, the processes tested, and the final conclusions. 3300 w. Munic Jour & Engr—May 2, 1906. No. 76492 C.

The Purification of Municipal Sewage (Städtische Abwasser und seine Reinigung). H. Bredtschneider. A discussion of the chemical and bacterial methods of sewage purification, and the conditions for which each method is applicable. Two articles. 7500 w. Gesundheits Ingenieur—March 17, 31, 1906. No. 76838 each B.

Sewers.

Brooklyn Sewer System. A. J. Provost, Jr. Information concerning the city's experience with vitrified clay and cement pipe. 2200 w. Munic Jour & Engr—May 2, 1906. No. 76490 C.

Concrete and Concrete Block Sewers in St. Joseph, Mo. Illustrated description of new sewers and the extension of main sewers, of plain concrete, reinforced concrete, or concrete blocks, built according to the system controlled by W. C. Parmley. 2000 w. Eng Rec—May 5, 1906. No. 76521.

Reinforced Concrete Pipe Sewers in St. Joseph, Mo. Describes the extension of sewers through land reclaimed on the Missouri River, the pipe used, and the method of laying it. 1200 w. Eng Rec—April 28, 1906. No. 76419.

The Ingersoll Run Sewer at Des Moines, Ia. A. E. Holmes. Illustrated description of the construction of a brick sewer, and of reinforced concrete sewers, explaining the requirements. 800 w. Eng Rec—May 28, 1906. No. 76417.

The Sewerage System of New Orleans. Explains the conditions and the topography of the city and gives an illustrated description of the system. 3500 w. Eng Rec—May 26, 1906. Serial. 1st part. No. 76955.

Street Traffic.

Street Traffic in New York City, 1885 and 1904. Clifford Richardson. Presents in detail data collected in 1904 on ten streets in New York City for the purpose of determining the traffic carried by a number of representative streets at that time; the results are also compared with those obtained by Francis V. Greene, in 1885. 2500 w. Pro Am Soc of Civ Engrs—May, 1906. No. 76932 E.

WATER SUPPLY.

Brooklyn.

Report on the Water Supply of Brooklyn Borough, New York City, for 1905. Interesting information from this report. Shows the pressing need of increasing the supply. 1200 w. Eng News—May 3, 1906. No. 76476.

Distilled Water.

The Economic Production and Uses of Distilled Water. Henry Leffermann. Introductory remarks on the demand for pure water, especially in large cities, and the means of purification, the uses and advantages of distilled water, and an illustrated description of an apparatus for producing such water in quantities. Discussion. 7000 w. Pro Engrs' Club of Phila—April, 1906. No. 76938 D.

Purification.

Device for Cleansing Stored Water. Illustrates and describes a system, devised by Timothy Lydon, for draining sediment in reservoirs and tanks. 1000 w. Fire & Water—May 12, 1906. No. 76623.

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New Water Purification Plant at Paris, Ky. Robert Spurr Weston. Describes a plant consisting of a coagulating basin, aerators, four rapid filters, and a clear water basin, which possesses original features of design. Ills. 2000 w. Eng News—May 3, 1906. No. 76475.

The Purification of Drinking Water in Large Volumes (Reinigung des Wassers in Grösseren Mengen). A. Oelwein. Advocating the use of alum as a coagulant, followed by mechanical filtration. 4000 w. Zeitschr d Oesterr Ing u Arch Ver—April 13, 1906. No. 76820 D.

Reservoirs.

Concreting the Jerome Park Reservoir. Brief illustrated account of the methods used in carrying out this extensive work. 1300 w. Sci Am—May 12, 1906. No. 76628.

The Development and Practical Construction of Valley Reservoirs (Die Geschichtliche Entwicklung, die Zwecke und der Bau der Talsperren). Dr. O. Intzé. A posthumous paper of the late Dr. Intzé giving an exhaustive review of experiences in the construction of artificial storage reservoirs by building masonry dams across valley outlets. Serial. Part I. 7000 w. Zeitschr d Ver Deutscher Ing—May 5, 1906. No. 76805 D.

Stray Currents.

Electrolysis: General Electrical and Lightning Protection. H. W. Spang. Describes the damage caused to water and gas pipes and other underground metal structures, explaining the causes. 2700 w. Am Gas Lgt Jour—May 7, 1906. No. 76505.

WATERWAYS AND HARBORS.

Coast Canal.

To Connect the Rio Grande and the Mississippi. C. S. E. Holland. Map and description of the proposed intercoastal canal connecting the Mississippi River and its tributaries with the coast region of Louisiana and Texas to the mouth of the Rio Grande. 900 w. Mfrs Rec—May 3, 1906. No. 76481.

Coasts.

Coast Erosion and Reclamation. Describes the physical causes at work, the present condition of the portions most seriously attacked, and the possibilities of remunerative protection. 3500 w. Engr, Lond—April 27, 1906. Serial. 1st part. No. 76578 A.

Dredger.

New Dredger for the Clyde. A new and very powerful barge-loading bucket dredger is illustrated and described. 800 w. Engr, Lond—April 27, 1906. No. 76581 A.

Submerged Chain Cable Groynes. R. G. Allanson-Winn. Discusses the force at work along the coasts, especially deep-sea erosion, and the method of protecting the land by the use of the chain cable groyne. 9 plates. 7000 w. Soc of Engrs —March 5, 1906. No. 77009 N.

Emden.

The Harbor Plant at Emden (Die Emdener Hafenanlage). E. Leber. An account of the cranes, cantilevers, conveyors and other mechanical appliances recently installed for the handling of coal and iron at the port of Emden, East Friesland. A good map of the docks, quays and other harbor improvements is given. 4000 w. 1 plate. Stahl u Eisen —May 1, 1906. No. 76809 D.

Genoa.

Extension of the Port of Genoa. Plan and description of improvements in progress. 2200 w. Engr, Lond—May 11, 1906. No. 76765 A.

Panama.

A Novel Plan for Excavating the Culebra Cut. Fremont Hill. An illustrated perspective sketch of the method suggested, which proposes the driving of a three-track tunnel at an elevation just above the surface of the natural water courses, with shafts at intervals, and Lidgerwood traveling cableway excavators. 2000 w. Eng News—May 17, 1906. No. 76677.

Machinery for the Panama Canal—Old and New. Fullerton L. Waldo. An illustrated account of the old machinery left by the French, and the American revival and newly installed appliances. 2500 w. Engineering Magazine—June, 1906. No. 76873 B.

Present Conditions on the Panama Canal Works. T. P. Shonts. Condensed from a special report made by the chairman of the Isthmian Canal Commission to the Secretary of War. 2200 w. Eng News—May 17, 1906. No. 76681.

Statement of Hon. William H. Taft, Secretary of War, Before the Committee on Interoceanic Canals of the United States Senate. Portions of this statement, with editorial comment. 14700 w. Eng News—May 10, 1906. No. 76619.

The Administration View of Panama Canal Affairs. Extracts from the statement of Secretary Taft before the Senate Committee on Interoceanic Canals. 6500 w. Eng Rec—April 28, 1906. No. 76420.

The Majority Report of the Senate Committee on the Type of the Panama Canal. Gives the portions of the report of most interest, the locks and dams, risk in construction, earthquakes, and cost. 4500 w. Eng News—May 24, 1906. No. 76783.

The Panama Canal Under Control of the United States. Henry L. Abbot. Gives a review of the work of the Commission appointed Feb. 9, 1904, and the reorganization of the commission in

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April, 1905. 4000 w. Harvard Engng Jour—April, 1906. No. 76694 D.

River Improvement.

Notes on the Regulation of Tidal Rivers (Bemerkungen Zu der Regulierumgswerken auf Tideströmen). A. v. Horn. Discussing especially the construction of embankments, levees, and jetties, for the maintenance of channels in streams subject to the ebb and flow of tides. 3000 w. 1 plate. Oesterr Wochenschr f d Oeffent Baudienst—April 28, 1906. No. 76835 D.

The Improvement of the Tennessee River and Power Installation of the Chattanooga and Tennessee River Power Company at Hale's Bar, Tenn. Thomas E. Murray. Describes work undertaken to improve the navigation of the river, and also applied to the development of electrical energy. Ills. 6500 w. Am Soc of Mech Engrs. No. 097—May, 1906. No. 76759 C.

The Rate of Filling the Salton Sink Basin by the Diversion of the Colorado River. Maps and report of the difficulties encountered in California in connection with an irrigation project, and the attempts to remedy the trouble. 1000 w. Eng News—May 10, 1906. No. 76618.

Ship Canal.

The Proposed Norwich and Yarmouth Ship Canal. Map and description of a scheme to build a ship canal in England, with a statement of the advantages expected. 2500 w. Engr, Lond—May 18, 1906. No. 77018 A.

Vienna.

The Improved Winter Harbor at Freudenau (Der Schutz und Winterhafen in der Freudenau). Illustrating and describing the improved docks and harbor works at Freudenau on the Danube, at Vienna. 4000 w. 4 plates. Oesterr Wochenschr f d Oeffent Baudienst—

ELECTRICAL ENGINEERING

COMMUNICATION.

Cables.

The Last Link of the All-American Pacific Cable. Lewis G. Martin. An illustrated account of the laying of an underground cable to connect the Manila-Shanghai submarine cable with the cable office in Shanghai. 1800 w. Elec Rev, N Y—May 19, 1906. No. 76724.

Cable Steamer.

See Marine and Naval Engineering.

Relay.

A Telephone Relay. John Trowbridge. Reviews the development of the telephonic relay, considering the principles involved in its construction, and describes the relay invented by the writer. Ills. 3000 w. Am Jour of Sci—May, 1906. No. 76691 D.

Signaling.

Apparatus for Electric Signaling and Firing for Mortar Batteries. William C. Davis. States the important requisites for signaling and for firing apparatus, and describes the proposed apparatus for electric signaling and firing for mortar batteries. Ills. 4000 w. Jour U S Art—March, 1906. No. 76793 D.

Space Telegraphy.

Atmospheric Electricity and Trees. Prof. A. G. McAdie. An illustrated discussion of the effect of sunshine on transmission of wireless messages, the behavior of trees during thunder storms, wireless experiments with trees, etc. 3800 w. Elec Wld—April 28, 1906. No. 76590.

Massie Wireless Telegraph System. Illustrated description of this system as used at the present time. 2000 w. Elec Wld—April 28, 1906. No. 76589.

On a Method of Obtaining Continuous Currents from a Magnetic Detector of the Self-Restoring Type. L. H. Walter. Read before the Royal Soc. Describes a method by which the author has succeeded in obtaining continuous unidirectional currents from a detector in which the energy available is derived in part from the external field. 1500 w. Elect'n, Lond—May 18, 1906. No. 76992 A.

On Methods Whereby the Radiation of Electric Waves May Be Mainly Confined to Certain Directions, and Whereby the Receptivity of a Receiver May Be Restricted to Electric Waves Emanating from Certain Directions. G. Marconi. Read before the Royal Soc. Reports results obtained by substituting a horizontal direct-excited air wire directed toward the receiving station, at a comparatively small distance above the surface. Diagrams. 2000 w. Electn, Lond—May 4, 1906. No. 76663 A.

Wireless Telegraphy. Reginald A. Fessenden. Gives a brief description of some of the work done by the writer relative to the determination of laws governing the propagation of wireless disturbances, with some new facts hitherto unpublished. 3000 w. Elec Rev, Lond—May 11, 1906. Serial. 1st part. No. 76755 A.

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Wireless Telegraphy from the Andaman Islands to the Mainland of Burma. Copy of a report relating to this installation, with map showing the position. 2500 w. Elect'n, Lond—April 27, 1906. No. 76563 A.

Telephony.

Experiments on the Inductive Vienna-Innsbruck Telephone Line. Describes a series of interesting tests carried out on a line "loaded" inductively according to the Pupin system. 700 w. Elect'n, Lond—May 4, 1906. No. 76662 A.

Standardization of Methods and Appliances in Telephony. Frank R. McBerty. A discussion of the considerations tending toward the standardizing of appliances, and also some of the disadvantages. General discussion follows. 6800 w. Jour W Soc of Engrs—April, 1906. No. 76931 D.

The Lorimer Automatic Telephone. An illustrated explanation of the action and advantages of a new invention by two Americans, now on trial at Paris. 1600 w. Sci Am—May 26, 1906. No. 76787.

The Telephone System of Today. C. J. H. Woodbury. Remarks on the early attempts at transmission of sound, the telephone instrument, transmitter, administration of the telephone system, lines, switchboard, uses, rates, etc. Discussion. 14000 w. Pro Engrs' Club of Phila—April, 1906. No. 76937 D.

Testing.

American Practice in the Detection of Faults in Telephone Lines (Gebräuchliche Amerikanische Verfahren zur Bestimmung von Fehlern in Fernsprechleitungen). Max Freimark. Describing methods of testing and localizing faults by the use of Wheatstone bridge, using the methods of Murray and Varley. 3000 w. Elektrotech Zeitschr—April 19, 1906. No. 76850 B.

DISTRIBUTION.

Accumulators.

Storage Batteries for Polyphase Currents (Anwendung von Pufferbatterien bei Drehstrom). L. Schroeder. Describing an improved arrangement of motor-generator with special shunt regulator, acting on the field of the direct current portion of the motor-generator. 3000 w. Elektrotech u Maschinenbau—April 15, 1906. No. 76846 D.

Cables.

Rubber Insulated Cables Without Lead. James S. McLean. Gives the writer's observations on the installation of non-leaded rubber-insulated cable, with reasons why the lead sheath is needed, and the care that should be given it. 1200 w. Elec Wld—May 26, 1906. No. 76978.

Connections.

Some Electrical Puzzlers. E. S. Lincoln. Explains puzzling cases occurring in the writer's experience. 1400 w. Power—June, 1906. No. 76749 C.

Faults.

Causes and Prevention of Faults on Direct-Current Networks. F. Fernie. Observations referring to a direct-current three-wire network, with the neutral wire earthed at one place, and 460 volts between the outer wires. 2800 w. Elect'n, Lond—May 11, 1906. No. 76756 A.

Regulation.

The Regulation of the Pressure of Discharge of Lighting Batteries. Ernest P. Hollis and E. R. Alexander. Read before the Newcastle Sec. of the Inst. of Elec. Engrs. The booster method, and the regulating cell method are considered and compared. 2000 w. Elec Engr, Lond—May 18, 1906. Serial. 1st part. No. 76988 A.

Rules.

Board of Trade Extra-High-Pressure Regulations. A copy of recently issued regulations under the Electric Lighting Acts, with editorial comment. 3000 w. Elect'n, Lond—April 27, 1906. No. 76565 A.

Sub-Stations.

Some Interesting Features in the Design of a 3000 Kilowatt Sub-Station. S. J. Lisberger. Describes interesting features of sub-station No. 2, Oakland, Cal. Ills. 2700 w. Wis Engr—June, 1906. No. 76697 D.

The Boston Edison Company's Natick Station. Illustrates and describes interesting features of a station which supplies light and power to some seven or eight towns of Massachusetts, near Boston. 1200 w. Elec Wld—April 28, 1906. No. 76591.

Transformers.

Switching Arrangements for the Reduction of Losses in Single-Phase and Polyphase Transformers (Schaltungsanordnungen zur Vermeidung bezw. Verringerung der Leer laufsarbeit bei Ein und Mehrphasen Wechselstrom-Transformatoren). J. Schmidt. Discussing automatic switch devices for the control of current for transformers when running under light or no load. Serial. Part. 1. 2500 w. Elektrotech u Maschinenbau—May 6, 1906. No. 76849 D.

The Theory of Shop Methods of Testing Single and Polyphase Transformers. J. W. Rogers. Reviews facts connected with the working and the losses occurring in a transformer, and describes the tests generally carried out, giving diagrams. 2000 w. Elec Engr, Lond—May 4, 1906. Serial. 1st part. No. 76661 A.

Voltage Regulation in Transformer Stations (Spannungsregelung in Trans-

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formator Stationen). Heinrich Hinden. With graphical diagrams discussing the Tirrell regulator and the use of boosters for the maintenance of voltage. Two articles. 7500 w. Elektrotech Zeitschr—April 26, May 3, 1906. No. 76853 each B.

Wiring.

Notes on Wiring with Lead-Covered Rubber Insulated Wire. Presents the advantages of this system, comparing with other systems in use. Ills. 1500 w. Elec Rev, Lond—April 20, 1906. No. 76437 A.

ELECTRO-CHEMISTRY.

Anodes.

Truswell's Anode Mold. R. Truswell. Illustrated description of a new mold developed for the purpose of casting anodes. 700 w. Engr & Min Jour—May 5, 1906. No. 76547.

Electric Furnace.

The Electric Furnace: Its Evolution, Theory and Practice. Alfred Stansfield. Gives the history of the electric furnace, with general description and classification, its efficiency, cost, design, construction, operation, uses, etc. Ills. 3500 w. Can Engr—May, 1906. Serial. 1st part. No. 76624.

Industries.

The Electrochemical and Electrometallurgical Industries in 1906. John B. C. Kershaw. Gives details of the present position in these industries, with interesting illustrations. 5500 w. Cassier's Mag—May, 1906. No. 76484 B.

Laboratory.

Laboratory of Applied Electro-Chemistry at Columbia University. Prof. Samuel A. Tucker. Illustrated description of laboratory for the study of practical electro-chemistry, and for research work and some of the appliances used. 1500 w. Elec-Chem & Met Ind—May, 1906. No. 76427 C.

Scrap.

Electrical Recovery of Scrap Metal. George E. Walsh. Information concerning the increasing use of the electric current for recovery works. 2200 w. Min Wld—May 26, 1906. No. 76980.

Smelting.

Electric Lead Smelting. Anson G. Betts. A report of experiments with the Betts-Valentine process, describing the process and giving results. Also editorial. 6000 w. Elec Chem & Met Ind—May, 1906. No. 76426 C.

ELECTRO-PHYSICS.

Flux Distribution.

Notes on the Distribution of the Magnetic Flux in Direct-Current Machines with Commutating Poles. Dr. R. Pohl. An explanation of the distribution of the commutating flux considering unloaded machines and armature reaction. Ills. 2500 w. Elec Engr, Lond—April 20, 1906. No. 76435 A.

Induction.

Self Induction or Armature Reaction (Selbstinduktion oder Ankerruckwirkung?) Hermann Zipp. A discussion of the theory of Peukert, considering the secondary circuits of continuous and alternating currents. 2000 w. Elektrotech Zeitschr—May 3, 1906. No. 76856 B.

Insulation.

The Influence of Polish upon the Insulating Properties of Wood (Einfluss der Politur auf die Isolierenden Eigenschaften von Holz). Karl Wernicke. A discussion of experiments, showing that polishing does not materially affect the insulating properties of wood. 1500 w. Elektrotech Zeitschr—May 17, 1906. No. 76860 B.

Resonance.

A Resume of Electrical Resonance. Frank F. Fowle. Describes the occurrence of resonance and the conditions that cause it, its uses and dangers. 1500 w. Elec Rev, N Y—May 19, 1906. Serial. 1st part. No. 76723.

GENERATING STATIONS.

Armatures.

Putting on a Direct-driven Generator Armature. H. L. Strong. Explains the writer's experience in the first attempt to force on the armature of a small-sized generator. 900 w. Power—June, 1906. No. 76748 C.

Boosters.

Notes on Booster Developments. A. H. Kelsall. Abstract of a paper read before the Glasgow Sec. of the Inst. of Elec. Engrs. Explains the action of the reversible booster, and the devices for making the booster changes automatic and its uses. 2400 w. Elect'n, Lond—April 20, 1906. No. 76440 A.

Notes on Booster Developments. A. H. Kelsall. Reviews a paper by this author read before the Glasgow Loc. Sec. of the Inst. of Elec. Engrs. Refers to old and new methods, and especially considers the Lancashire "automatic booster." 1500 w. Elec Engr, Lond—May 18, 1906. No. 76987 A.

Commutators.

Mechanical design of Commutators for Direct-Current Generators. R. Livingstone. The present number states the requirements of a satisfactory commutator, discussing each briefly, and explaining the causes of stress in different parts of a commutator. 1000 w. Elect'n, Lond—May 18, 1906. Serial. 1st part. No. 76991 A.

Converters.

Shunt and Compound-Wound Synchronous Converters for Railway Work. W. L. Waters. Discusses and compares

the advantages and disadvantages of the two methods of excitation. Considers the best system for general work is to have shunt-wound converters, standard transformers, and no reactance coils. 1600 w. Pro Am Inst of Elec Engrs—May, 1906. No. 76941 D.

Synchronous Converters Versus Motor Generators. Clarence P. Fowler. A comparison of their efficiency, floor space and cost, inherent regulation and voltage control, overload capacity, methods of starting, hunting, power factor, frequency, and reversibility. 3300 w. Elec Wld—May 26, 1906. No. 76977.

Three to Six Transformation and Connections to Rotary Converters. Guy J. Reynolds. Explains the three ways of transforming from three to six-phase current. 600 w. Elec Wld—May 19, 1906. No. 76742.

Economy.

The Effect of Day Load on Central Station Economy. J. P. Jones. A symposium presented before the convention of the Iowa Electrical Association. 4000 w. Elec Rev, N Y—May 12, 1906. No. 76601.

Efficiency.

Discussion on "Power Plant Economics," at Pittsburg, Pa., February 13, 1906. Discussion of Henry G. Stott's paper on this subject. 5400 w. Pro Am Inst of Elec Engrs—May, 1906. No. 76942 D.

Generating Set.

The New Steam-Dynamo Group at the Moabit Station in Berlin (Die Neuen Dampfdynamogruppen der Zentrale Moabit in Berlin). Illustrating especially the 6000 horse-power horizontal triple-expansion steam engines by Sulzer Bros. with direct-connected A. E. G. alternators. 1200 w. 2 plates. Schweiz Bauzeitung—May 5, 1906. No. 76832 B.

Generators.

The Design of Electric Generators. W. O. Horsnaill. On the use of comparative formulæ in the mechanical design of electric generators. 2500 w. Engng—May 11, 1906. No. 76761 A.

Three-Wire Direct-Current Generators. A. H. McIntire. Based on a lecture by W. A. Dick. Illustrates and describes these machines and their working. 1000 w. Elec Jour—May, 1906. No. 76706.

Governors.

Electromagnetic Control of Governors. Harry R. Speyer. Explains the action of the electro-magnetic control of the governor of the steam engine which drives the dynamos. Ills. 1100 w. Elec Engr, Lond—April 20, 1906. No. 76436 A.

Hydro-Electric.

Hydro-electric Plant of the City of Drammen, Norway. Franz Koester. Illustrated, detailed description of an installation including a generating station, a step-up transformer system, a long-distance high-tension transmission line, step-down transformer sub-stations and low-tension distributing system. 2500 w. Elec Rev, N Y—May 12, 1906. No. 76600.

The Electric Station at Wangen, on the Aar (Das Elektrizitätswerk Wangen on der Aare). K. Meyer. An illustrated description of the new power plant at Wangen, Switzerland, where 4,500 horse power is developed from the Aar, for distribution in the Cantons of Solothurn and Bern, and in German Alsace. Serial. Part I. 3000 w. Zeitschr d Ver Deutscher Ing—May 12, 1906. No. 76815 D.

Hydraulic Features of the Plant of the Pike's Peak Hydro-Electric Co., Manitou, Colo. Plan and section of the station, with description and illustrations. 2500 w. Eng Rec—May 19, 1906. No. 76734.

Plant of the Pike's Peak Hydro-Electric Company. Illustrated detailed description of a plant at Manitou, Colorado, which employs the highest head of water yet attempted, the static head being 2417 ft., and other features of interest. 4000 w. Elec Wld—May 26, 1906. No. 76975.

The Hydro-Electric Developments at Trenton Falls, N. Y. Illustrated description of an interesting electrical development in Central New York. Also editorial. 2000 w. Elec Wld—May 19, 1906. No. 76740.

Installation.

Practical Installation of Electrical Apparatus. Thomas W. Poppe. Gives a method applicable to any size of generator likely to be handled by the ordinary central station. Ills. 800 w. Elec Wld—May 5, 1906. No. 76551.

Newcastle.

The Newcastle Electric Supply Company. 2500 w. Elec Engr, Lond—May 11, 1906. No. 76754 A.

Production.

Central Station Light, Heat and Power Principles. Newton Harrison. Discusses things of importance in the production of electricity on a large scale. 1700 w. Cent Sta—May, 1906. No. 76597.

Scotland.

Electric Light and Power in the Highlands. W. B. Esson. An illustrated description of the plant furnishing light and power to the towns of Dingwall and Strathpeffer Spa. 2500 w. Elec Mag—April 24, 1906. No. 76482 A.

Testing.

A. Scheme for Testing the Efficiency of Electrical Power Plants and for Keeping the Necessary Records. Wilmot E. Ellis. Outlines the scheme of tests and records that has been in operation in the Artillery District of Portland since Dec. 5, 1905, giving blanks used. 2800 w. Jour U S Art—March, 1906. No. 76792 D.

We supply copies of these articles. See page 637.

Turbine Plant.

Turbine Plant of the Oshkosh Gas Light Co. Illustrated description of a plant for supplying light and power to a city of 30,000 inhabitants. 1600 w. Engr, U S A—May 1, 1906. No. 76465 C.

Ventilation.

The Ventilation of Turbo-dynamos (Ventilation von Turbo-dynamos). F. Niethammer. Discussing the arrangement of axial air inlets and radial discharge passages in the armatures of high-speed dynamos for direct connection to steam turbines. 3500 w. Elektrotech u Maschinenbau—April 22, 1906. No. 76847 D.

LIGHTING.

Arc Lamps.

A New Form of Electric Arc Lamp (Ueber eine Neue Form einer Elektrische Bogenlampe). E. Stadelmann. A mass of fire-clay or other incandescent material is placed adjacent to the arc, and when heated, becomes a partial conductor of incandescent effect. 1500 w. Elektrotech Zeitschr—May 3, 1906. No. 76855 B.

Arc Lighting. R. H. Henderson. Considers details of arc lamps, their operation and maintenance, classification, etc. 3000 w. Elec Jour—May, 1906. No. 76703.

Long Flame Arc Lamps. Leonard Andrews. Read before the Inst. of Elec. Engrs. Considers improvements effected, showing that increased efficiency is directly or indirectly due to increased length of arc. 2200 w. Elect'n, Lond—April 27, 1906. Serial. 1st part. No. 76564 A.

Church Lighting.

Notes on the Lighting of Churches. Edwin R. Weeks. Discusses the requisites in church lighting, the systems of electric lighting for interiors, illustrating by an application. Ills. 1700 w. Pro Am Inst of Elec Engrs—May, 1906. No. 76940 D

Desk Lighting.

The Lighting of Desks. J. R. Cravath and V. R. Lansingh. States the requirements and considers a number of illustrations showing prevailing methods. 1000 w. Elec Wld—May 5, 1906. No. 76550.

India.

The Electric Lighting of Lashkar City, Gwalior, Central India. Illustrates and describes the system adopted, which is a three-wire continuous current with 450 volts across the outers. 1000 w. Elec Rev, Lond—April, 27, 1906. No. 76561 A.

Intensity.

The Distribution of Illumination in the Neighborhood of Two Lamps. J. R. Benton. Explains how to ascertain the maximum intensity of illumination at any point, and how to find the proper candlepower to produce a given intensity of illumination. 2000 w. Elec Wld—May 5, 1906. No. 76549.

Mercury Arc.

Observations on the Mercury Arc and Some Resultant Problems in Photometry. C. Orme Bastian. Read before the Glasgow Sec. of the Inst. of Elec. Engrs. Shows that the mercury arc lamps will prove useful in combating other illuminants, and gives an interesting study of its luminosity. 3500 w. Elect'n, Lond—May 11, 1906. No. 76758 A.

The Production of Red Light in the Mercury Vapor Lamp. (Ueber die Erzeugung Roten Lichtes in der Quecksilberlampe). E. Gehrcke and O. von Baeyer. The color of the light is improved by adding zinc to the mercury; also a small amount of sodium to correct the yellow rays. 600 w. Elektrotech Zeitschr—April 19, 1906. No. 76852 B.

Nernst.

Rare Earths and Electric Illuminants. Murray C. Beebe. Discusses the properties of some of the rare earth oxides, various experimental tests, and experiments with the Nernst glower. 6000 w. Wis Engr—June, 1906. No. 76699 D.

Rates.

Equitable Rates in Relation to Rate Regulation. George M'Lean. Read before the Iowa Elec. Assn. An explanation of the lighting corporations' position, and a discussion of rate regulation. 2500 w. Elec Rev, N Y—May 12, 1906. No. 76602.

Residence Lighting.

Residence Lighting and Other Central Station Work at Wabash, Ind. An illustrated article describing the plant in a town of 9,000 inhabitants, where residence lighting forms a large proportion of the business. 2000 w. Elec Wld—May 12, 1906. No. 76652.

Theatre Lighting.

Electricitv at the New York Hippodrome. An illustrated article showing the extent to which electricity is used in this amusement building, for utilitarian, decorative, and advertising purposes. 3500 w. Elec Wld—May 5, 1906. No. 75548.

MEASUREMENT.

Photometers.

A Practical Installation of the Ulbricht Spherical Photometer (Eine Ausführungs fonn des Ulbrichtschen Kugelphotometers). Dr. M. Corsepius. Describing the apparatus at the Cologne Polytechnic. The sphere is two meters in diameter. Data and results of a number of tests are given. 3500 w. Elektrotech Zeitschr—May 17, 1906. No. 76859 B.

The Determination of the Hemispherical Intensity of Luminous Bodies (Zur Berechnung der Hemisphärischen Intensität Körperlicher Lichtquellen). Dr. H. Heimann. Deriving methods of computing the hemispherical intensity from measurements made of several zones. 3500

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w. Elektrotech Zeitschr—April 19, 1906. No. 76851 B.

Symbols.

Standard Electrical Symbols (Einheitliche Formelzeichen). K. Strecker. A report to the *Elektrotechnischer Verein*, suggesting an elaborate system of standard symbols for physical and electrical magnitudes. 10000 w. Elektrotech Zeitschr—May 10, 1906. No. 76857 B.

Temperature.

Measurement of Temperature by Electrical Means. Edwin F. Northrup. Considers electrical methods of measuring temperature, electrical resistance thermometry, construction of resistance thermometers, slide-wire bridge methods, use of dial or decade Wheatstone bridges, etc. Ills. 770 w. Pro Am Inst of Elec Engrs—May, 1906. No. 76939 D.

Transformers.

The Testing of Transformers and Transformer Iron. D. K. Morris and G. A. Lister. Abstract of a paper read before the Birmingham Sec. of the Inst. of Elec. Engrs. Describes a diagram found useful in transformer problems, and proposes a standard test involving one set of connections, three instruments, and the normal supply. 3200 w. Elect'n Lond—April 27, 1906. No. 76566 A.

Voltage.

The Estimation of the Reactance Voltage of Continuous Current Dynamos. H. M. Hobart. Describes a method having the merits of simplicity of the formula and saving in time. 700 w. Elect'n, Lond—April 20, 1906. No. 76439 A.

Weak Currents.

An Improved Measuring Appliance for Weak Alternating Currents (Ein Neues Messgerät für Schwache Wechselströme) W. Voege. The current is measured by the rise in temperature of a platinum wire enclosed in a vacuum bulb, using a thermo-electric pile and mirror galvanometer. 1800 w. Elektrotech Zeitschr—May 17,1906. No. 76858 B.

MOTORS.

Direct-Current.

Care of Direct-Current Motors. John Howatt. Calls attention to the troubles due to dirt and dampness, the causes of sparking, etc. 2000 w. Power—June, 1906. No. 76750 C.

Induction Motor.

Simple Circular Current Locus of the Induction Motor. A. S. M'Allister. Discusses the use of the simple circular locus of the primary and secondary currents of the motor for determining the complete performance of the machine. 1300 w. Elec Wld—May 26, 1906. No. 76976.

Interpole.

The Auxiliary-Pole Type of Motor. J. M. Hipple. The effect of the auxiliary field in producing sparkless commutation, the efficiency of the auxiliary-pole motor, etc., are discussed. 1200 w. Elec Jour—May, 1906. No. 76704.

Tests of an Interpole Railway Motor G. Herbert Condict. Gives characteristic curves of a 35 H. P. interpole motor showing its remarkable performance when operated under weak field conditions. Also the possibilities of control. 700 w. St Ry Jour—May 26, 1906. No. 76964 C.

Single-Phase.

The Action of Single-Phase Collector Motors with Reference to Short-Circuiting under the Brushes (Das Verhalten des Einphasen-Kollektormotors unter Berücksichtigung der Kurzschlussstrome unter den Bürsten). Dr. Max Breslauer. An elaborate discussion of the single-phase motor, using the analysis of the circle diagram. 8000 w. Elektrotech Zeitschr—April 26, 1906. No. 76854 B.

Windings.

The Calculation of Polyphase Induction Motor Windings. F. T. Chapman. Indicates a rapid method of determining approximately the most suitable winding from the standpoint of the power factor and overload capacity, for a motor whose mechanical dimensions are already fixed. 600 w. Elect'n, Lond—May 18, 1906. No. 76990 A.

TRANSMISSION.

Cables.

Admissible Limits of Pressure for Armored Cables (Limites Admissibles pour les Tensions de Service des Cables Armés). M. de Marchena. A review of practical experiences showing the successful use of pressures up to 22,000 volts. 7000 w. Bull Soc Int des Electriciens—April, 1906. No. 76863 G.

Lightning Arresters.

Earthing Resistances for Lightning Protectors (Erdleitungswiderstände bei Blitzschutzvorrichtungen). Gustav Bernischke. Discussing the advantages of carborundum as a material for resistances, with practical details as to its use in connection with lightning arresters. Discussion. 6000 w. Elektrotech Zeitschr—May 17, 1906. No. 76862 B.

Superposition.

The Application of the Principle of Superposition to the Transmission of Alternating Currents over a Long Line (Application du Principe de la Superposition à la Transmission des Courants Alternatifs sur une Longue Ligne). A. Blondel. Deriving a graphical method, giving a form of diagram for practical use in computing the pressure and current at the end of the line. 1200 w. Comptes Rendus—May 7, 1906. No. 76829 D.

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INDUSTRIAL ECONOMY.

Address.

The Unifying of the Republic. Silas G. Comfort. President's address. An interesting review of engineering development and achievement during the last thirty years as introductory to a consideration of the advancement made from 1800 to about 1830, describing conditions of one hundred years ago, the engineering achievements, etc. 7800 w. Pro Engr's Club of Phila—April, 1906. No. 76935 D.

American Industries.

Personal Reminiscences of the Past Half-Century. James Christie. Remarks on the industrial conditions in the United States, about fifty years ago. Deals with transportation, iron manufacture, ship and boat building, mining, agriculture, etc. 8500 w. Pro Engr's Club of Phila—April, 1906. No. 76936 D.

Classification.

Classification of Engineering Expenditures. F. H. Newell. Discusses the object and methods of classification. 3000 w. Eng Rec—April 28, 1906. No. 76413.

Development.

Industrial Development. Explains a scheme in connection with the development of the North-Eastern districts, England, with the object of establishing new industries, where rates are low and electric power cheap, and where railway and water facilities are abundant. Maps. 1500 w. Elec Rev, Lond—April 27, 1906. No. 76560 A.

Education.

Education and Training of Engineers. The essential part of the report of the Committee on the Education of Engineers, appointed by the Institution of Civil Engineers. Also editorial. 4500 w. Engr, Lond—April 27, 1906. No. 76579 A.

Fire Losses.

Fire Losses in the United States. A Grave National Question. Joseph K. Freitag. A discussion of the lessons of the San Francisco disaster, showing the general lack of real fire-proof construction throughout the country. 3500 w. Engineering Magazine—June, 1906. No. 76871 B.

Government Work.

An Army View of American Government Engineering. Maj. W. L. Sibert. An advocacy of government control of engineering work and of its practical efficiency. 2500 w. Engineering Magazine—June, 1906. No. 76874 B.

Inventory.

Plant Inventory—Importance. Value and Method of Keeping a Going Inventory. F. B. Johnson. Gives forms of card records and shows its usefulness and value. 1200 w. Am Mach—Vol. 29. No. 21. No. 76771.

Italy.

Italian Industries. On the rapid commercial development of Italy, and the causes. The present article discusses the utilization of the abundance of water. Ills. 3500 w. Engr, Lond—April 20, 1906. Serial. 1st part. No. 76449 A.

Labor.

Railway Servants Hours of Labor. Discusses the question as related to England. 2300 w. Engr, Lond—May 11, 1906. No. 76767 A.

Piece Work.

Piece Work. J. Bertram. Explains a piece-work plan in which the price is fixed per piece. 1200 w. Am Mach—Vol. 29. No. 18. No. 76470.

Public Utilities.

A Bill Providing for Government Development and Ownership of Water Power in Ontario. A discussion of a bill representing one of the most extensive experiments in public ownership of utilities ever tried. 1000 w. Eng News—May 24, 1906. No. 76777.

Transportation.

Transportation, and Its Relation to Manufacture. Jno. J. Baulch. Shows their dependence upon each other, and considers especially conditions at St. Louis. Discussion. 11600 w. Pro St Louis Ry Club—April 13, 1906. No. 76692.

MARINE AND NAVAL ENGINEERING

Battleships.

Contract Trial Performance of the United States Battleship Louisiana. A. F. Bowen and H. B. Gregory. Gives detailed description of the vessel, its armor, ordnance, equipment, etc., with report of trials. Also editorial. 7800 w. Int Marine Engng—May, 1906. No. 76421 C.

The Japanese Battleship "Katori." Fully illustrated article giving detailed description of the ship, its armor, armament, etc., with report of steam, trials. 5700 w. Engng—May 11, 1906. No. 76762 A.

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Boilers.

See Mechanical Engineering, Steam Engineering.

Cable Steamer.

Twin-Screw Cable Steamer Grand Duke of Oldenburg (Doppelschrauben Kabeldampfer Grossherzog von Oldenburg). General description and details of cable-laying steamer built by Schichau for the North German Marine Cable Company. There are three cable tanks of 850 cubic metres capacity. 2000 w. 1 plate. Schiffbau—May 9, 1906. No. 76833 D.

Capstans.

English and American Capstans and Electric Winches. Frank C. Perkins. Illustrates and describes types used. 1000 w. Int Marine Engng—May, 1906. No. 76423 C.

Cruiser.

French Armored Cruiser. Ernest Renan. Illustrated detailed description of this recently launched vessel, the largest and most powerful yet laid down in France. 1700 w. Engr, Lond—April 20, 1906. No. 76452 A.

Curiosities.

Curiosities of Naval Architecture—Round Ships and Globular Vessels. C. Field. Brief illustrated descriptions of vessels of these types constructed or proposed. 2500 w. Sci Am—May 5, 1906. No. 76499.

Engines.

See Mechanical Engineering, Combustion Motors.

See Mechanical Engineering, Steam Engineering.

Experimental Tank.

Ship-Model Experimental Tank at the Clydebank Shipyard. Reviews results of tank work, and gives an illustrated detailed description of this tank at Clydebank. 6000 w. Engng—April 27, 1906. No. 76570 A.

Freeboards.

Notes on the Freeboard Rules. J. Foster King. Read before the Inst. of Naval Archts. Notes upon an examination of the German Rules for Freeboard, and their bearing upon the general question. 4000 w. Engng—April 27, 1906. No. 76576 A.

Launch.

A Forty-Foot Cruising Launch. John Q. Walton. Description, with illustrations, of a recently completed vessel. 1300 w. Int Marine Engng—June, 1906. No. 76775 C.

Liner.

The Holland-America Liner Nieuw Amsterdam. Illustrated detailed description of this fine vessel, recently placed in service between Rotterdam and New York. 2800 w. Int Marine Engng—June, 1906. No. 76772 C.

Marine Railway.

The Overland Transport of Vessels by Marine Railway (Bemerkungen über den Trockentransport bei Schiffseisen bahnen). E. Wehrenfennig. With illustrations of a type of marine railway intended as a substitute for canal service, using inclined planes in place of locks. 1800 w. 1 plate. Oesterr Monatschr f d Oeffent Baudienst—April 21, 1906. No. 76834 D.

Motor Boats.

A Paraffin Motor Launch. Illustrated description of a small launch built for the Soudan Government, intended for service at Khartoum. 700 w. Engr, Lond—May 18, 1906. No. 77020 A.

High-Speed Motor-Boats. James A. Smith. Read before the Inst. of Nav. Archts. Discusses the design and construction, mainly of high-speed launches with internal-combustion motors. Ills. 3500 w. Engng—April 20, 1906. No. 76454 A.

On Steering and Manœuvering of Power Boats. Norman L. Skeene. A study of the lateral plane, the action of the propeller, and the action of the rudder. Diagrams. 1700 w. Rudder—May, 1906. No. 76588 C.

Naval Machinery.

Standardization of Naval Machinery. Deals with the standardization of the machinery of H. M. armored cruiser "Duke or Edinburgh," reporting trials. Ills. 3800 w. Engng—May 4, 1906. Serial. 1st part. No. 76667 A.

Naval Training.

A New Scheme of Naval Training. J. A. Ewing. Lecture at the Royal Naval College, Portsmouth. Discusses the new scheme recently inaugurated in England, giving an account of its very satisfactory development and of the training at the colleges at Osborne. 4000 w. Engr, Lond—May 18, 1906. Serial. 1st part. No. 77022 A.

Navies.

Comparison of the French and German Navies. J. Peltier. Gives a comparison from the report of the French Minister of Marine, with a supplement showing how the American navy compares with the other two. 1800 w. Int Marine Engng—June, 1906. No. 76773 C.

Navigation.

Shaping the Course. Clarence E. Long. Describes the manner of safely conducing the navigation of any vessel from port to port. 4800 w. Marine Rev—May 17, 1906. Serial. 1st part. No. 76714.

Ore Carrier.

The Ore-Carrying Steamer Narvik (Der Erzdampfer Narvik). H. Herner. A fully illustrated description of a 6000 ton ore carrier on the Doxford turret model, built by Krupp for the transport

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of the Lapland iron ores from Narvik to Rotterdam. 1800 w. Zeitschr d Ver Deutscher Ing—May 5, 1906. No. 76807 D.

Propellers.

The Molding of Propellers. Outlines the two general methods of molding and casting the screw propeller—the use of the pattern and that of the sweeps. Ills. 4000 w. Int Marine Engng—76424 C.

Reconstruction.

Lengthening of the Steamer Hamilton. Alexander Wills. Illustrated description of this method of increasing the carrying capacity of a ship of the Old Dominion Steamship Co. 2000 w. Int Marine Engng—June, 1906. No. 76774 C.

River Steamer.

The Hendrick Hudson. Illustrated detailed description of this recently launched vessel, said to be the largest river steamer in the world. 3300 w. Int Marine Engng—May, 1906. No. 76425 C.

Shipyard.

Fore River Ship Building Company's Yard. An illustrated description of this modern yard, near Boston, with special reference to its electrical equipment. 2500 w. Marine Rev—May 3, 1906. No. 76515.

Signalling.

Submarine Signalling by Means of Sound. J B. Millet. An account of the experiments in this field, and the invention as used and its operation. Also letters bearing testimony of its value and aid to navigation. Discussion. Ills. 5000 w. Jour Soc of Arts—May 4, 1906. No. 76653 A.

Stability.

Stability Calculations by Planimeter. R. E. Anderson. Discusses a proposed method which requires a planimeter of the least expensive type, and is based on the principle of the familiar property of the curve of displacement. 3000 w. Int Marine Engng—May, 1906. No. 76422 C.

Steamers.

The London County Council Passenger Steamers. Archibald Hogg. A criticism of the steamers designed for this service, with general discussion. Ills. 3000 w. Trans N E Coast Inst of Engrs & Shipbldrs—March 16, 1906. No. 76695 D.

The Turbine-Driven Channel Steamer "Viper." Illustration, with description and report of trials. The vessel is to be used in the mail service between the Clyde and Belfast. 800 w. Engng—May 18, 1906. No. 77014 A.

Tail-Shafts.

Vickers' Appliances for Preserving and Lubricating Tail-Shafts. Illustrates and describes an arrangement for enabling oil to be used as a lubricant in the stern-tubes of steamers without its leaking away into the sea, and also preventing sand entering the stern-tube. 1500 w. Engng—May 4, 1906. No. 76669 A.

Yachts.

Steam Yachts: Some Comparisons. J. R. Barnett. Read before the Inst. of Naval Archts. Makes comparisons showing the most important changes made during the last twenty-five years. 2200 w. Engng—May 4, 1906. No. 76668 A.

MECHANICAL ENGINEERING

AUTOMOBILES.

Austin.

The Austin Petrol Cars. Begins an illustrated description of a British model, the leading characteristics, and details of construction. 1800 w. Auto Jour—May, 5, 1906. Serial. 1st part. No. 76654 A.

The Austin 25-30 H. P. Car. Describes interesting details of these cars, illustrating the petrol tank arrangement. 2000 w. Autocar—April 28, 1906. No. 76555 A.

Bicycle Gear.

The Pedersen Three-Speed Bicycle Gear. Illustrated description of an ingenious gear. 2000 w. Engng—May 11, 1906. No. 76764 A.

Brake Horsepower.

Brake Horsepower of Four-Cycle Motors. George W. Rice. Explains formula developed by the writer, and chart. 500 w. Automobile—May 24, 1906. No. 76796.

Carbureter.

The Carbureter and Its Functions. An explanation of the principles involved in modern carbureters, with remarks. Ills. 2000 w. Automobile—May 3, 1906. No. 76486.

Clement-Talbot.

The Clement-Talbot Petrol Cars. Principally an illustrated detailed description of the new 20 H. P. all-British vehicle. with general information in regard to the works and output of this company. 1200 w. Auto Jour—May 12, 1906. Serial. 1st part. No. 76753 A.

De la Buire.

The De la Buire Cars. Illustrates and describes details of these interesting French Cars. 2500 w. Autocar—May 19, 1906. No. 76985 A.

Depreciation.

Car Depreciation. J. T. Ward. Discusses detail of depreciation and thinks as long as it does not exceed 15 to 20 per cent per annum, it is not excessive.

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1500 w. Autocar—April 21, 1906. No. 76434 A.

Education.

An Automobile School. An account of a school opened in New York for training in the principles involved in the construction and operation of automobiles of all types. Ills. 1000 w. Sci Am—May 26, 1906. No, 76786.

Electric.

The Electric Vehicle. Hayden Eames. Discusses its present status and its relation to the central station, the care needed and requirements. Ills. 3300 w. Elec Jour—May 1906. No. 76705.

Engines.

The Körting Paraffin Engine. Illustrates and describes a twelve-cylinder engine working in a special two-stroke cycle. 500 w. Autocar—May 5, 1906. No. 76656 A.

Gears.

The Humphrey-Scowen Gear Mechanism. Illustrations, with description. The chief features are the prevention of gear changing without declutching, and the facilitation of changing. 1200 w. Autocar—April 28, 1906. No. 76556 A.

Heavy Vehicles.

The Heavy Motor Vehicle Industrially Considered. John McGeorge. A comparative illustrated study of the advantages of electric propulsion as compared with steam and oil motors. 5000 w. Engineering Magazine—June, 1906. No. 76876 B.

Horse-Power.

Cubical Contents and Horse-Power. D. M. Weigel. A suggested method for calculating the actual power of engines by the cubical contents of their cylinders. 2000 w. Autocar—April 21, 1906. No. 76432 A.

Hotchkiss.

The Hotchkiss Cars. A brief illustrated description. 1300 w. Autocar—May 5, 1906. No. 76655 A.

Matheson.

Self-Starting is a Feature of This Car. An illustrated description of the starting device of cars built in Wilkes-Barre, Pa. 1700 w. Automobile—May 24, 1906. No. 76707.

Motor Cars.

Mechanical Features of Some of the Winning Cars in the Automobile Club of America's Two-Gallon Fuel Contest. Illustrated description of interesting features. 2000 w. Sci Am Sup—May 19, 1906. No. 76690.

Motor Races.

The Motor Races at Monaco. An illustrated account of the races with remarks on the development in motor craft. 5000 w. Autocar—April 21, 1906. No. 76433 A.

Omnibuses.

Motor Omnibuses for Public Passenger Service. R. G. L. Markham. An illustrated review of the history of motor vehicles for carrying passengers, their recent development and advantages. 3300 w. Cassier's Mag—May, 1906. No. 76483 B.

The "Electrobus" and Its Financial Prospects. Discusses the prospects of the electric omnibus in London, the running costs, re-charging expenses, cost of up-keep, mechanical features, etc. Ills. 2000 w. Auto Jour—April 28, 1906. No. 76558 A.

The 35-H. P. Napier Petrol 'Bus. Illustrated detailed description of the chassis, which is specially designed to take a double-deck 'bus body. 1000 w. Auto Jour—April 28, 1906. No. 76557 A.

The Transport of Passengers and Luggage by Heavy Motor Vehicles (Personen und Güterbeförderung mit Schweren Motorwagen). A. Heller. An illustrated discussion of the capabilities of the motor omnibus, showing vehicles used in Berlin, London and Brussels, with details of motors, tires, and gearing. Serial. Part I. 3000 w. Zeitschr d Ver Deutscher Ing—May 5, 1906. No. 76806 D.

Works.

The Daimler Motor Car Works. Illustrated description of these fine works which have recently been extended. 2500 w. Engr, Lond—May 4, 1906. No. 76664 A.

COMBUSTION MOTORS.

Design.

Current Practice in Petrol Engine Design. G. W. Rice. Derives rational machine formulae for the different parts of a petrol engine with the constants of the formulæ derived from practice. 2500 w. Sib Jour of Engng—May, 1906. Serial. 1st part. No. 77027 C.

Engines.

British Marine Oil and Spirit Engines. Edward Butler. Presents the advantages and disadvantages of vapor motors, and experience previous to the introduction of the explosion principle, and since, giving illustrated descriptions of various designs of motors. 7500 w. Rudder—May, 1906. No. 76587 C.

Gas Engines.

A Heavy Duty Gas Engine Installation in the Carnegie Technical Schools' Plant, Pittsburgh, Pa. Illustrated detailed description of the four-cylinder double acting 500 H. P. engine. 2800 w. Ir Age—May 17, 1906. No. 76673.

Korting Gas Engine. Illustrates a 350-H. P. intermediate type, and a 250-H. P. engine embodying the latest modifications. 300 w. Engr, Lond—May 18, 1906. No. 77019 A.

We supply copies of these articles. See page 637.

Producer Gas.

Gas Producers for Power Purposes Oskar Nagel. Briefly refers to the Dawson, and Mond processes, and gives an illustrated description of a modern producer made by Ernest Koerting, and gives information relating to such plants. 1500 w. Eng News—May 17, 1906. No. 76679.

The Production of Power Gas from Lignite (Die Vergasung der Braun-Kohle zu Motorische Zwecken). H. Neumann. A discussion of various forms of gas producers, purifiers, and auxiliary apparatus for the generation of power gas from lignites and brown coals. Serial. Part I. Zeitschr d Ver Deutscher Ing—May 12, 1906. No. 76816 D.

The Use of Producer Gas for Power Generation. Godfrey M. S. Tait. Shows that the variable element in producer gas is due to the continually changing volume of the hydrogen constituent, and describes the Combustion Utilities Co.'s process for the regulation of flame and combustion temperatures, giving results obtained. 2200 w. Eng Rec—May 19, 1906. No. 76735.

Suction Gas.

Developments in the Construction of Suction Gas-Producers. William A. Tookey. Abstract of a paper before the Jr. Inst. of Engrs., with editorial. Showing the stage to which design has arrived as the result of experience. 7000 w. Jour of Gas Lgt—April 24, 1906. No. 76533 A.

Vaporizer.

Gardner's Vaporizer for Oil Engines. Illustrated detailed description. 900 w. Mech Engr—April 28, 1906. No. 76559 A.

See also Mechanical Engineering, Automobiles.

HEATING AND COOLING.

Bank Heating.

Heating and Ventilating the National Park Bank, New York. Illustrated description of a system of direct radiation, with auxiliary indirect apparatus for ventilating, used in a T-shaped building. 1000 w. Heat & Vent Mag—May, 1906. No. 76700.

Churches.

Church Sanitation. William Paul Gerhard. A discussion of church hygiene, and also the design, materials, and various matters relating to these buildings. Heating and ventilation are especially considered. 3300 w. Am Archt—May 26, 1906. No. 76961.

City Hall.

Low Pressure Heating and Ventilating Plant at the New City Hall at Frankfurt-on-the-Main (Die Niederdruckdampfheizungs und Lüftungsanlagen im Neuen Rathause zu Frankfurt a. M.). With plans and sections of the buildings showing the arrangement of the radiators and the ventilating ducts. 1800 w. 2 plates. Gesundheits-Ingenieur—March 24, 1906. No. 76839 D.

Custom House.

Heating and Ventilating System of the New Custom House in New York. A seven-story granite and steel building in which the indirect heating system is used, except in a portion to be devoted to Post-Office purposes, where auxiliary direct radiation is installed. Ills. 5000 w. Eng Rec—May 26, 1906. No. 76959.

Exhaust.

The Theory of Heating with Exhaust Steam (Zur Theorie der Abdampfheizung). Dr. B. Biegeleisen. A comparison of the relative efficiencies of exhaust steam-heating and the condensation of exhaust steam for power production. 5000 w. Gesundheits-Ingenieur—March 31, 1906. No. 76840 D.

Radiator.

The Kaeferle Low-Pressure Radiator (Kaeferles Patent Niederdruckdampf Heizkörper). Describing an arrangement of injector nozzle by which the movement of the incoming steam effects a positive circulation in the radiator. 1500 w. Gesundheits-Ingenieur—April 28, 1906. No. 76841 D.

School.

The Heating and Ventilation of the New Tacoma High School. Briefly describes the building showing the difficulties to be met in heating, and illustrates and describes the system of direct and indirect radiation, operated by exhaust steam with the Webster vacuum system of steam circulation and Johnson pneumatic heat regulating apparatus. 4000 w. Eng Rec—May 5, 1906. No. 76524.

Thermostat.

The Automatic Regulation of the Temperature of Rooms (Die Selbst-regelung der Raumtemperatur). Describing an electric thermostat for the control of steam and hot-water radiators. 2000 w. Gesundheits-Ingenieur—April 28, 1906. No. 76842 D.

Trap.

See Mechanical Engineering, Steam Engineering.

Ventilation.

A Scotchman's Notes on Ventilation. Alexander MacKenzie. From a paper read before the Edinburgh Sanitary Soc. Discusses methods in use, compares the extraction and the plenum systems, favoring the former. 4000 w. Heat & Vent Mag—May, 1906. No. 76701.

HYDRAULICS.

Centrifugal Pumps.

Sulzer High-Pressure Centrifugal Pumps in Practical Service (Sulzer Hochdruck-Kreiselpumpen in Praktischen Betriebe). Julius Divis. A review of the

paper by Ziegler at the Liége Congress, showing efficiencies of more than 75 per cent against the heads of over 400 metres. Two articles. 3000 w. Oesterr Zeitschr f Berg u Hüttenwesen—April 14, 1906. No. 76827 each D.

Niagara.

The Diversion of Water from Niagara. Alton D. Adams. Gives a review of the plants along the water front of the park, aiming to show that only a small part of the water diverted in Queen Victoria Park could have found its way to the American Falls. 1600 w. Elec Wld—April 28, 1906. No. 76592.

Turbines.

A New Method of Turbine Control. Lamar Lyndon. Illustrates and describes a new method of turbine control, giving formulæ and facts on which the design is based. It consists primarily in changing rapidly the gate-opening of the turbine without changing the pressure or velocity of the water. 3500 w. Pro Am Inst of Elec Engrs—May, 1906. No. 76943 D.

Notes on the Characteristics of the Francis Turbine (Beiträge zur Charakterisk der Francis Turbine). Robert Löwy. Deriving constants for use in the classified formulas for turbine computations for wheels of the Francis type, according to the head and velocity. 2500 w. Elektrotech u Maschinenbau—April 15, 1906. No. 76845 D.

Pressure on the Pivot of the Jonval Turbine (Der Druck auf den Spurzapfen der Jonval Turbinen). Dr. Karl Kobes. A mathematical study of the water pressures in turbines of the Jonval type, showing the proportion of the vertical pressure to be supported by the step bearing of the shaft. 6000 w. 1 plate. Zeitschr d Oesterr Ing u Arch Ver—April 20, 1906. No. 76821 D.

Water Power.

The Commercial Utilization of the Hydraulic Power of the Upper Rhine from Neuhausen to Breisach (Die Wasser Kräfte des Oberrheins von Neuhausen bis Breisach und ihre Wirtschaftliche Ausnützung). H. E. Gruner. A review of the flow of the Rhine below the Falls and above Colmar, showing the points at which power developments are practicable. 2000 w. Schweiz Bauzeitung—May 12, 1906. No. 76844 B.

MACHINE WORKS AND FOUNDRIES.

Castings.

Some old Bronze Castings. Illustrates and describes interesting castings found at Pompeii and Herculaneum. 1200 w. Foundry—May, 1900. No. 76709.

Chains.

Chain Making: Its History and Development. Andre Jockaru. Illustrated description of the Lelong chain machine, the latest device for rapid production. 4800 w. Ir Trd Rev—May 3, 1906. No. 76487.

Chain-Making Machinery. Emile Lelong. Illustrates and describes the Lelong chain-making machine and its operation, with remarks on the advantages and on other processes. 2000 w. Ir & St Inst—May, 1906. No. 76918 N.

Core-Making.

Mechanical Core-Making Machines. Illustrates and describes a variety of these machines. 2500 w. Ir & Coal Trds Rev—May 11, 1906. No. 76926 A.

Cutting-Off.

An Analysis of the Cutting-Off Machine. Frederic R. Honey. An examination of the mechanism of the Pratt & Whitney cutting-off machine. 1500 w. Am Mach—Vol. 20. No. 19. No. 76609.

Drafting.

Economical Equipment and Management of the Drafting Room. T. D. Perry. Discussing especially systematic methods of storing and filing records, data, and drawings. 3000 w. Engineering Magazine—June, 1906. No. 76875 B.

Engraving.

A New Machine for Engraving Steel Plates. A. Frederick Collins. Illustrates and describes a machine invented by William S. Eaton, which is said to do the work better and cheaper than a skilled engraver. 1500 w. Sci Am—May 19, 1906. No. 76686.

Fire Arms.

The Manufacture of Colt's Automatic Army Pistol. An illustrated description of some of the interesting machine operations, and the machines used. 1700 w. Mach, N Y—May, 1906. No. 76464 C.

Forging.

Forging Presses. Illustrates a model of 3000-ton forging press, and describes the work done, and the improvements recently introduced. 3000 w. Engr, Lond—April 27, 1906. No. 76580 A.

Foundries.

A Modern Foundry Plant (Eine Moderne Giessereianlage). G. Rietkötter. A detailed description of an enlarged and rebuilt foundry plant, representing modern German practice, with plans and elevations of the buildings, and photographs of interior. Serial. Part I. 3500 w. 2 plates. Stahl u Eisen—May 1, 1906. No. 76811 D.

Foundry Costs. R. W. McDowell. Describes a cost system intended to meet the requirements of the general foundry. 5500 w. Foundry—May, 1906. No. 76708.

Foundry Department of the Ingersoll-Rand Co., Phillipsburg, N. J. Illustrated description of a plant for constructing a varied line of castings. 1700 w. Foundry—May, 1906. No. 76707.

Pipe Founding in Canada. Illustrated detailed description of the plant of the

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Montreal Pipe Foundry Co., Ltd., at Three Rivers, Province of Quebec, and the mode of manufacture. 3000 w. Can Engr—May, 1906. No. 76625.

Furnaces.

Tube Welding Furnaces (Die Gas rohrschweissofen). Anton Bousse. With illustrations of reverberatory furnaces for the heating of tubes prior to lap-welding. Serial. Part I. 3000 w. Stahl u Eisen—May 15, 1906. No. 76814 D.

Grinding.

The Grinding of Accurate Duplicate Tool Steel Parts. Joseph V. Woodworth. Illustrates and describes fixtures used to assist in the cheap production of interchangeable parts of tool steel. 1000 w. Ir Trd Rev—May 3, 1906. No. 76488.

Interchangeable Parts.

Manufacturing Interchangeable Machine Parts. John H. Barr. An introductory discussion of the development of labor-saving, especially in the United States, with remarks on the advantages of interchangeable parts, and a general consideration of the methods of duplicating. 7000 w. Sib Jour of Engng—May, 1906. No. 77026 C.

Iron Work.

Ornamental Iron Work. A topical discussion opened by W. N. Kratzer. 4000 w. Pro Engrs Soc of W Penn—May, 1906. No. 76907 D.

Lathes.

Electrically-Driven "All-Gear" Lathe. Illustration, with description of a lathe designed to do away entirely with the necessity for counterdrafting. There are sixteen direct spindle speeds. 800 w. Engng—May 11, 1906. No. 76763 A.

High-Speed Lathes. Illustrates and describes some special high-speed lathes for heavy bar turning and general work. 1000 w. Engr, Lond—May 11, 1906. No. 76768 A.

Large Gap Lathe. Illustrated description of a large sliding and surfacing lathe for turbine rotors and other work. 500 w. Engng—April 20, 1906. No. 76455 A.

Machine Design.

The Relation of Mechanics to Machine Construction (Die Mechanik in ihrer Bedeutung für den Maschinenbau). H. Lorenz. An address showing the great practical utility of the modern science of mechanics and kinematics in connection with the construction machines. 5000 w. Zeitschr d Ver Deutscher Ing—April 28, 1906. No. 76802 D.

Milling Machine.

Heavy Motor-Driven Milling Machine. An exceptionally powerful motor-driven duplex milling machine is illustrated and described. Built in Philadelphia. 400 w. Engng—April 27, 1906. No. 76575 A.

Press Feed.

An Automatic Press Feed. George Dean. Illustrated detailed description of an automatic strip feed for press. 1200 w. Am Mach—Vol. 29. No. 18. No. 76471.

Rolls.

Roll Grinding. C. H. Norton. States facts discovered during careful investigation of grinding rolls, with discussion of the reasons for the popular belief that rolls are practically perfect. 3000 w. Am Mach—Vol. 29. No. 18. No. 76469.

The Design of Bending Rolls. A. L. de Leeuw. Considers rolls of the pyramid type discussing their design, and illustrating the work by a practical example. 3800 w. Am Mach—Vol. 29. No. 20. No, 76685.

The Design of Billet and Bar Passes. B. H. Reddy. Gives a description of a method by means of which a series of such passes may be quickly proportioned. 1400 w. Mach, N Y—May, 1906. No. 76462 C.

Shops.

The Concrete Erecting Shop of the Ingersoll Milling Machine Company. Illustrated description of an example of reinforced-concrete construction, giving the specifications for reinforcement and other information. 1200 w. Mach, N Y—May 1906. No. 76461 C.

The Boiler Shop of the Titusville Iron Works. Joseph Y. Seyboldt. Illustrations with brief description. 500 w. Boiler Maker—May, 1906. No. 76598.

Stereotypes.

A New Device for the Making of Curved Stereotype Printing Plates for Newspapers. Describes the autoplate machine, and the recent Junior autoplate, for the use of offices where fewer plates are required. Ills. 1800 w. Sci Am Sup—May 26, 1906. No. 76790.

Tools.

The Thor Pneumatic Tools. Illustrates and describes improvements introduced in pneumatic drills and hammers. 1700 w. Ir Age—May 24, 1906. No. 76769.

Wheels.

Processes of Car Wheel Manufacture. Brief illustrated descriptions of the processes as carried out at various foundries. 5500 w. Ir & Coal Trds Rev—May 11, 1906. No. 76925 A.

MATERIALS OF CONSTRUCTION.

Alloys.

The Equilibrium Curves of the System Iron and Carbon. Prof H. v. Jüptner. A revision of results obtained in experimental investigations, discussing the equilibrium curves. 800 w. Ir & St Mag—May, 1906. No 76798 D.

We supply copies of these articles. See page 637.

Cast Iron.

Influence of Silicon Phosphorus, Manganese, and Aluminium on Chill in Cast Iron. E. Adamson. Describes experiments made to determine the influence of these metalloids on chill, and to obtain comparative data on mechanical tests and other conditions. 5400 w. Ills. Ir & St Inst—May, 1906. No. 76919 N.

The Influence of the Condition of the Carbon upon the Strength of Cast Iron as Cast and Heat Treated. W. H. Hatfield. Abstract report of research work. 2000 w. Ir & Coal Trds Rev—May 11, 1906. No. 76922 A.

Volume and Temperature Changes During the Cooling of Cast Iron. Thomas Turner. Remarks on attempts to measure shrinkage of cast iron, with description of apparatus adopted by the author, and method of determining temperature. Gives also particulars of the contraction and temperature changes of a few examples. 4000 w. Ir & St Inst—May, 1906. No. 76911 N.

Chemistry.

The Chemist in the Machine Shop. H. S. Brown. Shows the importance of having analyses of stock made in the construction of all machinery, and that it will add to the life of the finished machine and will reduce the cost. Ills. 2500 w. Ir Age—May 31, 1906. No. 77031.

Crucible Steel.

An Etching Method for Determining Whether Steel Has Been Made by the Crucible Process. James A. Aupperle. Describes the method used by the writer. 400 w. Ir & St Mag—May, 1906. No. 76799 D.

Heat Insulation.

Notes on Heat Insulation, Particularly with Regard to Materials Used in Furnace Construction. R. S. Hutton and J. R. Beard. Read before the Faraday Society. A report of experiments for the measurement of thermal conductivities of granular materials up to 100 degrees C. giving their relative value, and describing apparatus used. Ills. 1700 w. Sci Am Sup—May 5, 1906. No. 76503.

Pig Iron.

Grading Pig Iron. Reginald Meeks. Showing how much more reliable are irons mixed from grades by chemical analysis, than by the old method of grading by fracture. 1500 w. Eng & Min Jour—April 28, 1906. No. 76400.

Metallography.

Notes on Technical Details of Metallography (Einiges aus der Metallographischen Technik). P. F. Dujardin. Discussing details relating to the polishing of the metal surfaces and the arrangement of the microscope and camera for lighting and photographing the enlarged image. Serial. Part I. 3000 w. Stahl u Eisen—May 1, 1906. No. 76810 D.

Practical Application of Metallography in the Iron Industry (Ueber die Nutzanwendung der Metallographie in der Eisenindustrie). E. Heyn. A general review of the progress which has been made in the study of the physical constitution of the iron alloys, showing how the microscopic study of metals may be practically applied. 7500 w. Serial. Part I. Stahl u Eisen—May 15, 1906. No. 76812 D.

Steels.

Quaternary Steels. Leon Guillet. Abstract of research work on 12 varieties of these steels with conclusions. 6000 w. Ir & Coal Trds Rev—May 11, 1906. No. 76920 A.

Special Auto Steels and Their Properties. Rene M. Petard. Discusses special mixtures of steel, with reference to other materials. 2300 w. Automobile—May 10, 1906. Serial. 1st part. No. 76596.

Test-Pieces.

The Relation Between Type of Fracture and Micro-Structure of Steel Test-Pieces. C. O. Bannister. Report of researches, giving photographs of fractures of a number of types, with descriptions and examinations, with a summary of conclusions. 3500 w. Ir & St Inst—May, 1906. No. 76917 N.

Tool Steel.

High-Speed Steel in the Factory. O. M. Becker. Mr. Becker's sixth paper discusses the action of the tool at work, showing the conditions of maximum effect, and considering the proper care in the use of the tools. 3000 w. Engineering Magazine—June, 1906. No. 76877 B.

Wire.

The Heat Treatment of Wire, Particularly Wire for Ropes. J. Dixon Brunton. Abstract of research work made with a view to ascertaining the correct heat treatment. 3800 w. Ir & Coal Trds Rev—May 11, 1906. No. 76921 A.

Wood Pulp.

Brimstone versus Pyrite for Wood-Pulp Manufacture. Ernst A. Sjöstedt. A comparison of the value of brimstone and pyrite for sulphite pulp making. 1500 w. Eng & Min Jour—April 28, 1906. No. 76399.

MEASUREMENT.

Beams.

Sections of Cast Iron Beams. C. H. Benjamin. Presents results of interesting experiments made by students of the Case. School to determine the relative strength and stiffness of cast-iron beams having cross-sections of the same area but of different shapes. 2000 w. Mach, N Y—May, 1906. No. 76460 C.

Calorimeter.

Alcohol Calorimeter for Coal Testing. W. M. Wallace. Describes methods

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of using calorimeters, especially the good results obtained with the alcohol calorimeter. 1200 w. Engng—April 20, 1906. No. 76456 A.

Indicators.

The Calibration of Indicator Springs (Bestimmung üeber die Feststellung der Mass stäbe für Indikatorfedern). C. Bach. A report of the joint committee of the *Reichsanstalt* and the *Verein Deutscher Ingenieure* upon standard methods of standardizing the springs of steam-engine indicators; with practical examples and a brief bibliography. 3000 w. Zeitschr d Ver Deutscher Ing—May 5, 1906. No. 76808 D.

Metric System.

Tennessee Congressman Denounces Metric System. John Wesley Gaines. Objects to the French methods being made compulsory, showing the ample freedom existing under the present law. 2800 w. Am Mfr—May 10, 1906. No. 76595.

Pyrometers.

Improved Industrial Thermo-Electric Pyrometers (Nouveaux Pyrometres Thermo-Electriques Industriels). M. Pillier. Describing a pyrometer of the Le Chatelier type, in which the thermo-electric couple is made of an alloy of copper, nickel, and manganese. 4000 w. Bull Soc Int des Electriciens—April, 1906. No. 76864 D.

Speed Recorder.

A Speed and Mileage Recorder for Automobiles and Railroads. A new type of recorder recently introduced in Great Britain is illustrated and described. It is said to be infallible in its operation. 1200 w. Sci Am Sup—May 12, 1906. No. 76633.

A Unique German Speed Gauge. F. C. Perkins. Illustrated description of a speed gauge for determining the speed of machines. It is an ingenious application of the property of resonance and was designed by Hermann Frahm. 700 w. Min Rept—May 3, 1906. No. 76538.

Springs.

The Calculations for Tension Springs for Electrical and Mechanical Apparatus (Berechnuug von Zugfedern für Elektrische und Mechanische Apparate). Robert Edler. Applying the usual formulas to the light wire helical springs used in electrical work, with computed tables for various materials. Serial. Part I. 3000 w. Elektrotech u Maschinenbau—April 29, 1906. No. 76848 D.

Standards.

The National Bureau of Standards at Washington. Illustrations of the buildings and equipment used, with description of the work being done. 4000 w. Am Mach—Vol. 29. No. 20. Serial. 1st part. No. 76684.

POWER AND TRANSMISSION.

Compressed Air.

Modern Methods of Rock Excavation. Describes the work accomplished by well drilling machines operated by compressed air on heavy contract work. Ills. 1700 w. Compressed Air—June, 1906. No. 77153.

The Comparative Merits of Air and Electric Drills. Granville E. Palmer. Considers the electric apparatus unsuited to this work. 800 w. Compressed Air—June, 1906. No. 77152.

Conveyors.

Coal-Handling Plant of the Long Island City Power House of the Pennsylvania Railroad. An illustrated article dealing in detail with the coal and ash-handling equipment of this station. 4000 w. Power—June, 1906. No. 76751 C.

Elevating and Conveying Machinery. S. F. Joor. Illustrated descriptive review of various types of this class of machinery both for carrying articles in bulk and for carrying packages of various kinds. Also discussion. 1200 w. Jour W Soc of Engrs—April, 1906. No. 76930 D.

Mechanical Handling of Coal, Ashes, and Clinker, at the Electricity Station, Ivry, of the Paris-Orleans Railway. The arrangement for automatic coaling and mechanical stoking is illustrated and described. 1800 w. Ir & Coal Trds Rev—May 18, 1906. No. 77025 A.

The Automatic Conveyor in Lumbering. Day Allen Willey. Illustrates and describes conveying machinery used in connection with lumbering, saw-mills, pulp factories, and other wood-working establishments. 900 w. Sci Am—May 5, 1906. No. 76497.

Cranes.

100-Ton Electric Derrick Crane at Scotts' Dock, Greenock. Illustrated description. 1000 w. Engng—April 27, 1906. No. 76572 A.

Electric Driving.

Electric Power for Clay Plants from an Engineers' Point of View. Victor C. Vance. Read before the Nat. Brick Mfr's. Assn. A consideration of the comparative merits of belt and electric transmission of power. 2500 w. Brick—May, 1906. Serial. 1st part. No. 76586.

Motor Drive in the Firth-Sterling Steel Company's Plant. Illustrated description of a typical installation of the Westinghouse direct-current motors, known as the S A type, in a new projectile shop at Demmler, Pa. 1500 w. Ir Age—May 31, 1906. No. 77029.

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Elevators.

Elevator Safeties at the Hotel Belmont. Describes the safety provisions for elevators operated at unusual heights and speeds. They are designed to carry 2,500 to 3,000 lbs. at a maximum speed of 500 ft. per minute. Ills. 2700 w. Eng Rec—May 19, 1906. No. 76738.

Gears.

A Method of Procedure in the Design of Helical Gears. R. E. Flanders. Describes a method which the writer thinks reduces the most serious of this class of problems to its simplest elements. 3500 w. Mach, N Y—May, 1906. No. 76463 C.

Hoists.

Lifts and Hoists. H. C. Crews. Abstract of a paper read before the Manchester Sec. of the Inst. of Elec. Engrs. Reports investigations and tests of an equal number of hydraulic and electric lifts as to energy, maintenance, total costs, etc. The commercial side of the subject mainly. 4000 w. Elect'n, Lond—April 20, 1906. No. 76441 A.

Mechanical Plant.

The Mechanical Plant of the Ford Memorial Building, Boston. Brief description of this 8-story, steel and brick building and its uses, with detailed description of the plant for ventilating, heating, lighting, elevator service and furnishing power for other machinery. Ills. 5500 w. Eng Rec—April 28, 1906. No. 76416.

STEAM ENGINEERING.

Boilers.

Boiler Setting. C. L. Hubbard. An illustrated article considering especially horizontal tubluar boilers. 900 w. Engr, U S A—May 15, 1906. Serial. 1st part. No. 76744 C.

Double-Ended Water-Tube Boiler. A report of the experimental tests made with the double-ended Yarrow boiler. 1200 w. Engng—April 27, 1906. No. 76574 A.

Horse Power of Boilers. Roger Atkinson. An explanation of methods of calculating. 800 w. Ry & Soc Engng—June, 1906. No. 77102 C.

Steam Boilers at the Liége Exposition (Ueber das Dampfkesselwesen auf der Weltausstellung zu Lüttich). With illustrations of the various boilers exhibited, including also superheatetrs and boiler attachments. 3500 w. Glückauf—April 21, 1906. No. 76822 D.

Cost.

Elements Influencing the Cost of Steam Power (Was Beeinflusst die Kosten der Dampfkraft?). H. Fischer. Deriving diagrams for use in showing the relative influence of boiler proportions, superheating, condensing, and engine performance upon the cost of steam power. 1500 w. Zeitschr d Ver Deutscher Ing—April 28, 1906. No. 76804 D.

Engines.

The Multiplication of Impulses. A. E. Ash. Reviews the development of the marine engine, showing the way the marine engineer has successfully multiplied the number of impulses and reduced the units of force. Ills. 1000 w. Autocar—April 21, 1906. No. 76431 A.

Exhaust Steam.

Utilizing Exhaust Steam in Low-Pressure Turbine Plant at Collieries. Hundt, in *Glückauf*. Illustrates and describes the plant at the Bruay collieries. The steam is derived from Rateau accumulators and discharged into high-vacuum condensers. 1600 w. Col Guard—April 27, 1906. No. 76569 A.

Governors.

Ruston and Recke's Shaft Governor. Illustrated description of a design of centrifugal shaft governor, recently patented. 1000 w. Mech Engr—May 5, 1906. No. 76659 A.

See Electrical Engineering, Generating Stations.

Losses.

Central Station Boiler-Room Losses. T. R. J. Orr. Calls attention to some sources of waste which can easily be kept in hand, which arise to alarming proportions if neglected. 3500 w. Elec Engr, Lond—May 4, 1906. No. 76660 A.

Lubrication.

Oil Required for Lubrication. Charles N. Bain. Calls attention to points to be considered in determining the amount of oil used. Ills. 1000 w. Elec Wld—May 5, 1906. No. 76552.

Nomenclature.

The Advantages of Employing Electrical Engineering Nomenclature in Steam Engineering Calculations. H. M. Hobart. Presents some of the advantages, with tables. 1700 w. Elec Rev, Lond—April 27, 1906. Serial. 1st part. No. 76562 A.

Powdered Coal.

Powdered Coal Firing for Steam Boilers. Geo. C. McFarlane. Illustrates and describes the burning of powdered coal with an air blast, and gives an estimate of comparative costs with hand-firing. 1000 w. Eng & Min Jour—May 12, 1906. No. 76607.

Smoke.

The Economy of Smoke Abatement. A. S. Atkinson. Discusses methods of securing perfect combustion of fuel. 2000 w. Boiler Maker—May, 1906. No. 76599.

Steam Heating.

See Mechanical Engineering, Heating and Cooling.

Superheating.

See Railway Engineering, Motive Power and Equipment.

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Testing.

Steam Consumption Test on a Twin Tandem Compound Condensing Winder at No. 1 Shaft, Village Deep, Ltd., on 15th February, 1906. Messrs. E. J. Laschinger, A. M. Robeson and H. C. Behr. Describes efficiency tests for winders of recent construction and gives results. Ills. 9000 w. Jour S. African Assn of Engrs—March, 1906. No. 76428 F.

Trap.

The Steam Trap. R. T. Strohm. Illustrated descriptions of types of this device, which is designed to remove the water of condensation from any vessel under pressure without allowing the escape of steam. 3000 w. Power—June, 1906. No. 76752 C.

Turbines.

Brake Tests of a 500-Kw. Westinghouse-Parsons Turbine. An account of some runs made at Atlanta, at the works of the Westinghouse Machine Co., with curve sheet. 1200 w. Eng Rec—May 19, 1906. No. 76737.

Condensing Machinery for Steam Turbines. Illustrated description of two types of sub-base condensers designed specially for working in conjkunction with steam turbines of the Curtis type. 700 w. Engng—April 20, 1906. No. 76453 A.

Some Practical Experiences with Steam Turbines. C. E. Stanton. Read before the Iowa Elec. Assn. Describes things learned in the practical operation of steam turbines. 2500 w. St Ry Jour—April 28, 1906. No. 76411 C.

Steam Turbines for Variable Loads. Illustrated description of a steam turbine patented by W. J. A. Loudon, designed to run efficiently at light loads. 1200 w. Mech Engr—April 21, 1906. No. 76442 A.

See also Electrical Engineering, Generating Stations.

Valves.

Setting the Valves of the Fleming Piston Valve Engines. Thomas Hall. Illustrated description of method. 2000 w. Power—June, 1906. No. 76747 C.

MISCELLANY.

Aeronautics.

The Flying and Soaring of Birds Explained by Well-Known Mechanical Principles. H. LaV. Twining. Presents results of experiments and observations, explaining the fundamental principles. Diagrams. 5000 w. Sci Am Sup—May 5, 1906. No. 76504.

Air Resistance.

Experiments to Determine the Relation Between Air Resistance and the Form of a Moving Body (Versuche zur Ermittlung der Abhängigkeit des Luftwiderstandes von der Gestalt der Körper). Albert Frank. Data and results of experiments upon prismatic and conical bodies, showing the reduced resistance for the latter forms. 4000 w. Zeitschr d Ver Deutscher Ing—April 21, 1906. No. 76800 D.

Engineers' Club.

Electrical and Mechanical Equipment of the New Engineers' Club Building, New York. Describes the general plan of this fine building in New York City, and the details of its electrical and mechanical equipment. Ills. 3000 w. Elec Wld—May 19, 1906. No. 76741.

Invention.

Discovery and Invention. Edward Goodrich Acheson. A lecture before the students of Sibley College. Briefly notes examples of discovery without invention, invention without discovery, and discovery with invention, and gives an interesting review of the writer's personal work. 4500 w. Sib Jour of Engng—May, 1906. No. 77028 C.

Oxygen.

The Production of Oxygen and Nitrogen from Liquid Air (Ueber die Herstellung von Sauerstoff und Stickstoff aus Verflüssigter Luft). F. Linde. A review of the progress which has been made in the fractional distillation and rectification of liquid air; discussing also the practical uses of the oxygen and nitrogen thus obtained. 2500 w. Zeitschr d Ver Deutscher Ing—April 28, 1906. No. 76803 D.

Photography.

Technical Photography. Frederick Henius. Discusses the photographing of machinery and interiors; the outfit needed, and factors of importance. Ills. 4000 w. Pro Engrs Soc of W. Penn—May 1, 1906. No. 76906 D.

Solar Heat.

The Utilization of Solar Heat for Industrial Purposes by Means of a New Plane Mirror Reflector. Carl Güntner. Illustrates and describes a new method of reflector construction, by the use of plane mirrors, discussing the application to practical uses. 6800 w. Sci Am Sup May 26, 1906. No. 76789.

Theater Plant.

Power Plant of the Majestic Theater Building. Illustrated detailed description of a plant that supplies light, heat and power to a 20-story office building and a 9-story theater in Chicago. 4000 w. Engr, U S A—May 15, 1906. No. 76743 C.

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MINING AND METALLURGY.

COAL AND COKE.

Alaska.

The Matanuska Coal Field, Alaska. William Griffith. Maps and description of an extensive area underlaid by coal of good quality. 4800 w. Mines & Min—May, 1906. No. 76508 C.

Briquettes.

Briquetting of Brown Coal. K. A. Muellenhoff. Gives a description of the briquetting plant of the Lauchhammer Company, a well known iron and steel works in Saxony. The process is quite different from the briquetting of anthracite coal dust and slack coal, as no binder is necessary. Ills. Discussion. 5600 w. Pro Engrs Soc of W Penn—May, 1906. No. 76908 D.

Classification.

Classification of Coals. Marius R. Campbell. Proposes a scheme for accurately defining the classes of coal, which will apply to liquids as well as bituminous coal and anthracite. 2700 w. Min Rept—April 26, 1906. No. 76405..

Coal Cutting.

The Introduction of Coal-Cutting Machinery. J. S. Ward. Read before the Nat. Assn. of Col. Engrs. Considers the working of thin seams, the methods of getting coal, the essentials of a good coal-cutting machine, and related matters. Discussion. 5000 w. Ir & Coal Trds Rev—April 27, 1906. No. 76583 A.

Coal Measures.

The Occurrence of True Coal Measures at Port Seton, East Lothian. E. B. Bailey, and D. Tait. Abstracted from Trans. of the Edinburgh Geol. Soc. Describes the geology of this region. Map. 2000 w. Col Guard—April 20, 1906. No. 76448 A.

Coal Tests.

The Government Coal Tests. Samuel Sanford. A review of the report of the Coal Testing Operations of U. S. Geological Survey. 3300 w. Eng & Min Jour—April 28, 1906. No. 76401.

Disaster.

The Courrières Disaster. James Ashworth. Information of the character and extent of the mines, the probable cause of the explosion, and illustrated description of rescue apparatus. Also editorial. 3000 w. Mines & Min—May, 1906. No. 76513 C.

Electric Blasting.

Electric Blasting Apparatus, with Special Reference to its Use in Coal Mines. W. Maurice. The present number considers fuses and exploders. Ills. 2200 w. Elect'n, Lond—May 18, 1906. Serial. 1st part. No. 76989 A.

Electric Plants.

The Installation and Working of Electric Plants at Collieries. S. T. Boam. Read before N. Assn. of Col. Mgrs. Considers the generation of steam and the engine, the dynamo or generator, system of distribution motors, etc. 3500 w. Ir & Coal Trds Rev—April 20, 1906. No. 76458 A.

Explosives.

Bobbinite in Coal Mines. Gives evidence in regard to this explosive as used in coal mines, presented before the Home Office Committee. 8000 w. Ir & Coal Trds Rev—May 4, 1906. No. 76671 A.

Gases.

Some Practical Notes on the Detection and Estimation of Inflammable Gases in Mines by Means of Flame Caps. Prof. Charles Latham. Abstract of a paper before the Min. Inst. of Scotland. Points out improvements made in connection with safety lamps intended for flame cap testing. 2000 w. Col Guard—April 20, 1906. No. 76446 A.

Haulage.

Endless Rope Surface Haulage at Shilbottle Colliery. Describes the system of haulage, giving map showing route, and illustrations. 2800 w. Ir & Coal Trds Rev—May 4, 1906. No. 76672 A.

The Alliance Rack Rail Locomotive Haulage System. Shows that for grades in coal mines some form of mechanical haulage more positive than a traction locomotive is required, and presents the advantages of the system named, giving an illustrated description. 4500 w. Ir & Coal Trds Rev—May 18, 1906. No. 77023 A.

India.

Indian Coalfields. Map and information furnished by R. R. Simpson of the Geological Survey of India. Reports ten new fields and the re-examination of two previously known. 2000 w. Ir & Coal Trds Rev—April 27, 1906. No. 76582 A.

Indian Territory.

The Coal Fields of the McAlester Quadrangle, Indian Territory. H. A. Everest. Gives a general outline of the development and history of the field, and a description of the coals, their location, quality, and the methods of mining. 3000 w. Min Rept—May 17, 1906. No. 76718.

Mine Stables.

Underground Stables. Illustrates types of stables built of wood, iron, or concrete, and discusses the proper arrangement. 2000 w. Mines & Min—May, 1906. No. 76511 C.

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COPPER.

Arizona.

In the Globe, Arizona, District. An illustrated report of properties in this copper district. 1800 w. Min Rept—April 26, 1906. No. 76406.

Cornish Mines.

A Mine Below the Sea, with a Sketch of the Cornish Lodes. Arthur Lakes. An illustrated description of the Botallack mine which yields tin and copper with information concerning the Cornish mines. 900 w. Min Wld—May 5, 1906. No. 76541.

Lake Superior.

History of the Lake Copper District. An interesting account of the early work of Dr. Douglass Houghton, and the development of what has proved one of the most valuable mining fields in the world. 2500 w. Min Wld—May 12, 1906. No. 76641.

Matte.

The Determination of Matte. John P. Walker. Gives the formula used in calculating the grade of matte to be expected from a calcine of given percentage of copper and sulphur, and explains its application. 1000 w. Eng & Min Jour—May 5, 1906. No. 76546.

New Mexico.

The Burro Mountain District. Illustration, with description of this district. The chief metal is copper, but a pay deposit of lead-silver ore occurs, and also a high grade lead ore. 2400 w. Min Rept—May 24, 1906. No. 76974.

Nickel Ores.

Genetic Relations of Some Nickel-Copper Ores. Charles W. Dickson. Read before the Can. Min. Inst. Briefly reviews the geological relations of nickel ores in general, and discusses the deposits of St. Stephen, N. B., and Sohland, Germany. 7800 w. Can Min Rev—May, 1906. No. 76973 B.

Ore Treatment.

Note on the Ammonia-Copper-Cyanide Process. E. Le Gay Brereton. A report of experimental investigations and results, which show that under certain conditions cuprous potassium cyanide in an ammoniacal solution is broken up with the liberating of an alkaline cyanide. 1500 w. Inst of Min & Met—March 15, 1906. No. 76995 N.

Note on the Ammonia-Copper-Cyanide Process. E. Le Gay Brereton. H. L. Sulman's discussion of this paper. 1700 w. Inst of Min & Met—March 15, 1906. No. 76997 N.

Production.

Arizona and Sonora. Dwight E. Woodbridge. The present article discusses the production of copper, and gives information concerning several of the districts. Ills. 1200 w. Eng & Min Jour—May 12, 1906. Serial. 1st part. No. 76605

The Direct Production of Copper. An illustrated detailed description of the Cowper-Coles centrifugal process for electrically depositing copper. 1700 w. Engng—May 18, 1906. No. 77013 A.

Quebec.

Copper Deposits of the Eastern Township of Quebec. John Alexander Dresser. Map of the district, with account of the early work, a classification of the deposits, and a few of the characteristics of the ore bodies included in the first class. 2800 w. Ec Geol—March, 1906. No. 76946 D.

Recovery.

The Recovery of Copper from Mine Drainage. Philip Argall. Briefly reviews the history of the precipitation of copper from mine drainage, which has been established about 200 years in Europe, and recently introduced in the western mines of the United States. 2500 w. Min & Sci Pr—May 19, 1906. No. 76981.

Rhodesia.

Some Copper Deposits in Rhodesia. C. Brackenburg. Describes deposits in South Eastern Rhodesia, examined by the writer. 4000 w. Inst of Min & Met—May 17, 1906. No. 77005 N.

Smelting.

A New Method of Smelting Butte Ores. William A. Heywood. Describes the application of the Baggally process to the smelting of copper ores. 3000 w. Min & Sci Pr—April 28, 1906. No. 76639.

The Colorimetric Estimation of Copper in Slags. H. M. Kimball. Gives a simple method of running the daily slag samples for copper. 700 w. Eng & Min Jour—May 19, 1906. No. 76728.

Sudbury.

Notes on the Origin of the Sudbury Ores. David H. Browne. A study of the ores and of the theories explanatory of their origin, with the writer's conclusions. 2500 w. Ec Geol—March, 1906. No. 76948 D.

On the Origin and Relations of the Nickel and Copper Deposits of Sudbury, Ontario, Canada. Alfred Ernest Barlow. Gives a historical résumé of the literature relating to this mining district, describing the ore deposits. 4000 w. Ec Geol—March, 1906. No. 76947 D.

Tailings.

The Cyanide Treatment of Cupriferous Tailings by the Sulphuric Acid Process. W. S. Brown. Describes the treatment of tailings that come principally from Cobar, N. S. W. Reviews the operations. 2000 w. Inst of Min & Met—March 15, 1906. No. 76994 N.

Utah.

Modern Mining at Alta, Utah. Leroy A. Palmer. An account of the revival of an old camp, producing copper, lead, gold and silver, as well as other ores of value. Ills. 4500 w. Mines & Min—May, 1906. No. 76509 C.

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GOLD AND SILVER.

Alaska.

Gold-Mining in Alaska. Editorial, describing the deposits and giving an account of the difficulties in the different districts. 3000 w. Engng—April 27, 1906. No. 76573 A.

Vein Mining in Alaska. Chester W. Purington. Divides Alaska into three provinces, and discusses the prospects for vein mining in each. 1200 w. Min & Sci Pr—May 12, 1906. No. 76721.

Australia.

Progress of the Gold-Mining Industry of Western Australia. W. Burrell. Brief report of progress during the past year. Ills. 1500 w. Min Mag—May, 1906. No. 76903 C.

Black Hills.

Gold and Tin in the Northwestern Black Hills. Benjamin Sadtler. Report of the gold and tin bearing district in Crook County, Wyoming, and Lawrence County, South Dakota. The gold veins carry no tin, nor the tin veins any gold, but the placer regions carry both. The geology and development are described. Ills. 3500 w. Min Wld—April 28, 1906. No. 76407.

Chile.

The Mining District of Chanarcillo, Chile. Edward Halse. Deals with the distribution and concentration of the silver ores. 800 w. Min Jour—May 5, 1906. Serial. 1st part. No. 76657 A.

Cobalt.

The Cobalt-Mining District. Aldrea H. Brown. Information concerning this mining district of Ontario, Canada. Native silver, associated with argentite and various compounds of sulphur, arsenic and antimony, and smaltite, a diarsenide of cobalt, are the most valuable minerals. 1800 w. Min Wld—May 12, 1906: No. 76643.

The Occurrence and Development of the Cobalt Ore Deposits. . A. Macdonald. An illustrated account of the geological conditions in the cobalt district in northern Ontario, and the deposits of ores of silver, cobalt, nickel and arsenic. 3500 w. Engineering Magazine—June, 1906. No. 76878 B.

Concentration.

The Tempest-Apex Mill at Ouray, Colorado. Frank McLaughlin. Illustrated description of this concentrating mill, which treats a lead sulphide ore containing gold, silver, copper, lead and zinc. 1000 w. Min Rept—April 26, 1906. No. 76404.

Crushing.

Huntington Mill Notes. Cyril E. Parsons. Information in regard to Huntington Mills in Southern Rhodesia, with a detailed critical description of a single case. Ills. 6800 w. Inst of Min & Met—May 17, 1906. No. 77006 N.

Discussion.

A Record of an Investigation of Earth Temperatures on the Witwatersrand Gold Fields, and their Relation to Deep Level Mining in the Locality. Hugh F. Marriott. A discussion of this paper, introduced by the author. 5200 w. Inst of Min & Met—March 15, 1906. No. 76996 N.

Dredging.

Economy in Mining with Modern Gold-Dredges. George E. Walsh. Describes the modern gold dredging plant and its working, giving information concerning the cost for the plant, the working costs, etc. Ills. 2000 w. Min Wld—May 19, 1906. No. 76720.

The Bucket-Dredging Industry. E. Seaborn Marks and Gerald N. Marks. Discusses bucket-dredges and their construction, alluvial deposits suited to bucket-dredging, and the requisite conditions for successful operations; dredging operations and costs. Ills. 11000 w. Inst of Min & Met—April 19, 1906. No. 77002 N.

The Bucket-Dredging Industry. E. Seaborn Marks and Gerald N. Marks. Discussion of this paper. 6000 w. Inst of Min & Met—April 19, 1906. No. 77003 N.

Ecuador.

Gold-Dredging in Ecuador. Leonard L. Wetmore. Information concerning the placer fields and something of their history, showing the difference between modern methods of working placers and the crude methods adopted by the Spaniards. Ills. 3000 w. Min Mag—May, 1906. No. 76904 C.

Egypt.

Gold Mining in Upper Egypt. Ernest H. S. Simpson. From the Bul. of the Inst. of Min. & Met. Remarks on the results at Atallah, Eridea, and Semna, which give fair prospects of ranking high as producers. 2000 w. Min Jour—April 21, 1906. No. 76445 A.

Mexico.

Mining and Metallurgy in El Oro, Mexico. H. E. West. An account of the largest producer of gold in Mexico, and the third largest producer on the continent. Describes the district, deposits, ore treatment, sand treatment, power, etc. Ills. 7000 w. Min Mag—May, 1906. No. 76901 C.

The Peregrina Mill, Guanajuato. F. J. Hobson. Gives plan, cross-section, and description of the plant. The entire machinery is to be run with electric motors, the power being brought 103 miles. 800 w. Eng & Min Jour—May 19, 1906. No. 76730.

Montana.

The Cable Mountain Gold Mining District of Montana. W. D. Bohm. An illustrated historical account of this dis-

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trict, describing the ores, development, etc. 3000 w. Min Mag—May, 1906. No. 76902 C.

New South Wales.

The Mitchell's Creek Gold Mines, New South Wales. Wilfrid F. Macdonald. Gives the history, geology, and development of these mines, mining methods, treatment and costs. Ills. 4000 w. Inst of Min & Met—April 19, 1906. No. 77001 N.

Ore Treatment.

The Treatment of Temiskaming Low-Grade Ores. S. F. Kirkpatrick. Reports three methods of treatment investigated for these silver ores and gives a summary of the results obtained. 1400 w. Can Min Rev—May, 1906. No. 76971 B.

Parting.

A New Form of Platinum Parting Apparatus. A. Jarman. Illustrated description of a new form of tray, designed by Prof. Liversidge for use in the Sydnew Mint, with comparison with other forms. 1400 w. Inst of Min & Met—May 17, 1906. No. 77007 N.

Precipitates.

The Production of High-Grade Gold Bullion from Zinc-box Precipitates. C. J. Morris. Shows what can be done successfully, on a rather small scale, at a mine struggling to pay its way on a very low-grade ore. 1800 w. Inst of Min & Met—April 19, 1906. No. 76998 N.

Production.

Increased Production of Gold. R. W. Barrell. Discussing the effect increased production will have on the mining industry, and on the purchasing value of gold. 1800 w. Mines & Min—May, 1806. No. 76512 C.

Prospecting Shaft.

Notes on a Prospecting Shaft in the Goldfield District, Goldfield, Nevada. Edgar A. Collins. Describes the deposits and methods of mining and extraction, showing an unusual production. 1000 w. Inst of Min & Met—April 19, 1906. No. 76999 N.

Queensland.

Gold Deposits near Mount Ubi, West of the Blackall Range. B. Dunstan. Gives map and description of the auriferous country on Walli and Chinaman's creeks. 1500 w. Queens Gov Min Jour—March 15, 1906. No. 76430 B.

Separation.

The Separation of Gold in Antimony Ores. F. H. Mason. Gives an analysis showing the nature of the ore treated, and explains experimental investigations made, and the process finally pronounced successful. 3800 w. Min & Sci Pr—April 28, 1906. No. 76638.

Tin-Stone.

The Assay of Auriferous Tin-stone. C. O. Bannister. Read before the Inst. of Min. & Met. Reports results obtained by the author in comparing results obtained by different methods of assaying for gold in alluvial tin deposits. 1500 w. Min Jour—April 21, 1906. No. 76444 A.

IRON AND STEEL.

Blast Furnaces.

The Use of Oxygen in Removing Furnace Obstructions. C. de Schwarz. Read before the Iron & Steel Inst. Describes the application of compressed oxygen for the opening of closed tap-holes or tuyeres. 2000 w. Ir Age—May 17, 1906. No. 76674.

Cast Iron.

See Mechanical Engineering, Materials.

Compression.

Compression of Steel Ingots in the Mould. A. G. Capron. Explains the construction of the ingot moulds and press, stating the advantages obtained by the use of this system. Ills. 1500 w. Ir & St Inst—May, 1906. No. 76914 N.

Dry-Air Blast.

A Digest of the Criticisms of Gayley's Dry Air Blast Process. F. A. Wilcox. 5600 w. Ir & Coal Trds Rev—May 11, 1906. No. 76924 A.

Ferro-Manganese.

The Preparation of Carbon. Free Ferro-Manganese. E. G. Ll. Roberts, and E. A. Wraight. Abstract report of research work with ferro-manganese and the efforts made to deprive this alloy of its carbon. 3300 w. Ir & Coal Trds Rev—May 11, 1906. No. 76923 A.

Iron Ore.

The Ironstone of Mount Lucy, Chillagoe District. B. Dunstan. Geological survey report, describing the deposits in Queensland. Ills. 1000 w. Queens Gov Min Jour—March 15, 1906. No. 76429 B.

Magnetite.

Magnetite Deposits and Mining at Mineville, N. Y. J. H. Granbery. An illustrated series of articles on the nature and origin of these deposits near Lake Champlain. 2200 w. Eng & Min Jour—May 12, 1906. Serial. 1st part. No. 76603.

Manganese.

Preliminary Note on the Influence of Manganese on Iron. J. O. Arnold and F. K. Knowles. Reports tests made by a number of investigators, giving the composition of the alloys, and explains the method of preparing alloys of nearly pure iron and manganese. 1500 w. Ir & St Inst—May, 1906. No. 76916 N.

Rolling Mills.

The Design of Rolling Mills. W. H. A. Robertson. Calls attention to points needing improvement. 1000 w. Ir & Coal Trds Rev—April 20, 1906. No. 76459 A.

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Russia.

The Reconstruction of a Blast Furnace in Southern Russia (Modernes Umbau eines Hochofens in Sudrussland). Paul Thomas. With illustrations showing the workings at Kramatorskaia in the Government of Kharkoff, with details of the old and new furnaces. 2000 w. 1 plate. Stahl u Eisen—May 15, 1906. No. 76813 D.

Steel.

Crucible Steel. R. Barranger. Explains the manufacture of crucible steel, giving illustrated description of furnaces used, and information concerning the production. 4000 w. Foundry—May, 1906. No. 76710.

The Effect of Copper in Steel. F. H. Wigham. A report of research work, resulting in the conclusion that copper to the extent of 0.25 per cent is no disadvantage in the manufacture of the best classes of steel wire. 2000 w. Ir & St Inst—May, 1906. No. 76912 N.

Steel Sheets.

Brittleness and Blisters in Thin Steel Sheets. Edward F. Law. Reports an investigation of the causes, giving the conclusions from the results. Ills. 1800 w. Ir. & St Inst—May, 1906. No. 76913 N.

See also Mechanical Engineering, Materials.

MINING.

British Columbia.

A Reconnoissance into Tulameen, B. C. Horace F. Evans. Notes describing the country between Kamloops on the south, Thompson and the Tulameen River. The present number is introductory. 1500 w. Min Wld—May 26, 1906. Serial. 1st part. No. 76979.

Chains.

Chains. W. Macpherson. Read before the Nat. Assn. of Col. Mgrs. An illustrated paper on the use of chains at a colliery, their construction, upkeep, and the forms in which deterioration and decay manifest themselves. 4000 w. Ir & Coal Trds Rev—April 20, 1906. No. 76457 A.

Chert.

Chert Mining in England and Wales. Herbert L. Terry. Defines chert, and gives information about the occurrence, properties, and applications of the stone, and the methods followed in mining it. 4000 w. Inst of Min & Met—May 17, 1906. No. 77008 N.

Concentration.

The Sutton-Steele Process. R. C. Canby. Illustrations of the dry concentrating table and dielectric separator, and their operation. 1200 w. Eng & Min Jour—May 12, 1906. No. 76604.

Crusher.

A Very Large Gyratory Crusher. Illustrated description of a rock crusher, believed to be the largest in the world. 1400 w. Eng News—May 3, 1906. No. 76478.

Explosions.

Mine Explosions. J. T. Beard. Discusses the dangers and the factors that influence a mine explosion. 3500 w. Eng & Min Jour—May 19, 1906. No. 76731.

Faults.

The Fault System of Eastern Santa Eulalia. M. A. Knapp. Illustrated description of the geological formation of this silver-lead region in Mexico. 1200 w. Eng & Min Jour—May 26, 1906. No. 76968.

Hand-Drilling.

Methods of Hand-Drilling. W. R. Hulbert. Discusses the various systems of hand-drilling so as to give an idea of their relative merits. 900 w. Min & Sci Pr—May 12, 1906. No. 76722.

Head Frames.

Modern Types of Large Mine Head Frames. Bergassessor Brandi. Illustrated descriptions of types used at German mines. 2000 w. Min Mag—May, 1906. No. 76905 C.

Hydraulic Mining.

Hydraulic Mining in California. J. P. Hutchins. An account of this method of mining, the problems and difficulties, results, and present standing. Ills. 2800 w. Eng & Min Jour—May 19, 1906. No. 76729.

The Control of Hydraulic Mining in California by the Federal Government. Discussion of the paper by William W. Harts. 4500 w. Pr Am Soc of Civ Engrs—May, 1906. No. 76933 E.

Impact Screen.

On the Use of the Impact Screen in Tin-Dressing. J. H. Collins. Note on the first use of the impact screen in the United Kingdom, and, so far as known, its first application to tin-dressing. 400 w. Inst of Min & Met—April 19, 1906. No. 77000 N.

Lighting.

Acetylene Lighting in the Iron Mines of Lorraine (Azetylenbelenchtung beim Lothringischen Eisenerzbergbau). W. Serlo. With details of burners and portable acetylene generators, especially designed for mining use. 5000 w. Glückauf—April 28, 1906. No. 76823 D.

Lime Roasting.

The Huntington-Heberlein Process. Thomas Huntington and Ferdinand Heberlein. An account of this lime roasting process for the desulphurization of lead ores. Also editorial. 3500 w. Eng & Min Jour—May 26, 1906. No. 76970.

Matte.

A New Matte Separator. R. R. Hedley. Read before the Can. Min. Inst. Illustrates and describes a device invent-

ed by Henry Harris, successfully used in the Lead Smelting Works at Nelson, B. C. 1200 w. Can Min Rev—May, 1906. No. 76972 B.

New Mexico.

Mines and Reduction Works of the Comanche Mining and Smelting Company. Information concerning the enterprises of this company, especially in Grant and Socorro counties. 2000 w. Min Rept—May 3, 1906. Serial. 1st part. No. 76537.

New South Wales.

Mining at Broken Hill, New South Wales. Extracts from a speech by Mr. Harvey Patterson, explaining the conditions of mining. 2800 w. N Z Mines Rec—March 16, 1906. No. 76553 B.

Ore Deposits.

Ore Deposits and Their Distribution in Depth. Prof. John W. Gregory. Delivered before the Royal Inst. of Gt. Britain. Discusses the past, present, and future ore supply of the world. 1300 w. Min Jour—May 5, 1906. Serial. 1st part. No. 76658 A.

Perspective.

Perspective in Mining. J. Parke Channing. Address to the Engng. Soc. of Columbia Univ. Suggestions for young mining engineers. 4000 w. Min. Sci Pr—May 5, 1906. No. 76640.

Respirators.

The Chemistry and Mechanics of Respirator Life-Saving Appliances (Beiträge zur Chemie und Mechanik von Rettungsapparaten). M. Bamberger and F. Böck. A discussion of the reactions involved in the chemical regeneration of air for breathing, in connection with life-saving appliances for mines. 5000 w. Glückauf—May 12, 1906. No. 76826 D.

Rhodesia.

The Ancient Auriferous Conglomerates of Southern Rhodesia. J. W. Gregory. Discusses the genesis of the Rhodesian "banket," illustrating and describing samples taken. 6400 w. Inst of Min & Met—May 17, 1906. No. 77004 N.

Rock Drills.

A Carriage for Rock Drills. C. F. J. Galloway. Read before the South Wales Inst. of Engrs. An illustrated description of an application of the Brandt column, which is used in conjunction with drilling machines actuated by compressed air. 2500 w. Min Jour—April 28, 1906. Serial. 1st part. No. 76568 A.

Roasting.

Lime Roasting of Nickeliferous Matte. A. C. de Jongh. An acount of some experiments in working of nickel-copper matte. 700 w. Eng & Min Jour—April 28, 1906. No. 76396.

Safety Appliance.

The Undeutsch Safety Catch. Erminio Ferraris. Review of a book by Hermann Undeutsch, considering the rational construction of safety-catches on cages, and all matters relating to their efficiency and action. Ills. 3000 w. Eng & Min Jour—May 26, 1906. No. 76969.

Sampling.

Sampling with a Churn-Drill. Matt. W. Alderson. An illustrated article describing this method of sampling a large surface showing. 1000 w. Min Sci Pr—May 19, 1906. No. 76982.

Shaft Sinking.

An account of Sinking and Tubbing at the Methley Junction Colliery, with a Description of a Cast Iron Dam to Resist an Outburst of Water. Isaac Hodges. Abstract of a paper read before the Midland Co.'s Inst. of Engrs. 3500 w. Col Guard—April 20, 1906. No. 76447 A.

Applications of the Freezing Process to the Deepening of Two Shafts at Limburg, Holland (Die Anwendung des Gefrierverfahrens beim Abteufen zweier Schächte auf der Höllandischen Staatsgrube B, in der Provinz Limburg). H. Joosten. Describing the successful sinking of shafts 120 meters deep through quicksand by the use of the freezing process. 4000 w. Glückauf—May 12, 1906. No. 76825 D.

Shaft Timbers. Thomas Varcoe. Illustrates and describes methods of framing shaft timbers and making splices in the wall plates for very long shafts. 700 w. Min Jour—May 12, 1906. No. 76760 A.

The Application of Direct Cementation in Shaft Sinking. C. Dinoire. Abstract of a paper read before the Société de l'Industrie Minéral. Reports the application of direct cementation to a shaft where the water flow caused difficulties. 3500 w. Min Jour—April 21, 1906. No. 76443 A.

Stopes.

Handling Ore in Stopes. D. T. Williams. Abstract of a paper in the *Jour. of the Transvaal Inst. of Mech. Engrs.* An explanation of the difficulties and description of the mechanical devices introduced. 2200 w. Eng & Min Jour—May 5, 1906. No. 76545.

The Detailed Mapping of Stoping Areas. H. R. Sleeman. Deals with the graphic representation, in their true dimensions, of blocked-out ore reserves, considering the question solely in regard to inclined reefs. 2500 w. Inst of Min & Met—Feb. 15, 1906. No. 76993 N.

Timbering.

The Impregnation of Mining Timber (Ueber die Imprägnierung von Grubenhölzern). F. Seidenschnur. Discussing the importance of using preservatives for wood used for timbering mines, with photographs showing the increase in durability. 1800 w. Glückauf—May 5, 1906. No. 76824 D.

We supply copies of these articles. See page 637.

Underground Timbering. R. B. Nickerson. Describes methods of timbering heavy mines, methods of taking the measures for timbers underground, etc. 2000 w. Min & Sci Pr—May 19, 1906. No. 76983.

Ventilation.

Ventilation and Sanitation of Mines. Extracts from the report of the West Australian Royal Commission on the use of compressed air for ventilating purposes. 3500 w. Queens Gov Min Jour—April 18, 1906. No. 76986 B.

Winding.

85-Horse-Power Electric Winding Engine. Illustrates and describes an engine built for the Lens Colliery Company, in France. 1200 w. Engng—May 18, 1906. No. 77015 A.

Electric Winding. W. C. Mountain. A reply to published discussions and conclusions on a recent paper by the writer dealing with this subject. 1500 w. Ir & Coal Trds Rev—April 27, 1906. No. 76584 A.

MISCELLANY.

Arizona.

Sketch of the Geology and Ore Deposits of the Cherry Creek District, Arizona. John A. Reid. Considers the location, topography and geology of this interesting region, and the peculiar ore deposition. 6500 w. Ec Geol—March, 1906. No. 76944 D.

Asbestos.

The Mining Manufacture and Uses of Asbestos. J. Alfred Fisher. An illustrated article giving information concerning this mineral, especially its use as a covering for boilers, pipes, etc. 3700 w. Tram & Ry Wld—May 11, 1906. No. 76928 B.

Asphalt Veins.

The Formation of Asphalt Veins. George Homans Eldridge. The distribution, nature and origin of the fissures, dimensions of the veins, and relation to the enclosing strata are considered; comparison with metalliferous veins; the origin of the material, and the manner of its introduction. 3000 w. Ec Geol—March, 1906. No. 76945 D.

Diamonds.

Diamond Industry at Brazil. Arthur de Belmont Information concerning the localities where diamonds are found, their size, value, and the associated minerals. Ills. 1000 w. Min Wld—May 5, 1906. No. 76542.

Gems.

The Gems of Ceylon, Their Form of Occurrence and Methods of Extraction. Ralph Stokes. An interesting account of this industry, describing the deposits, and the methods. Ills. 3000 w. Min Wld—April 28, 1906. No. 76408.

Graphite.

Graphite—Its Occurrence and Uses. Charles C. Schnatterbeck. Discusses the occurrence, mining and refining, uses and values of this mineral. 1800 w. Min Wld—May 12, 1906. No. 76642.

Lead.

An Unique Lead Deposit. R. D. O. Johnson. Describes a deposit in Missouri, a mineralized clay bed, and the method of mining. 1200 w. Eng & Min Jour—April 28, 1906. No. 76397.

Visit to a Cornish Lead Mine and Experiences with a Man Engine. A. Lakes. Describes an unusual method of raising and lowering the men in the mines. 700 w. Min Rept—May 3, 1906. No. 76539.

Lead and Zinc.

Mississippi Valley Lead and Zinc District. Ralph E. Davis. Describes the deposits in Wisconsin, Illinois, and Iowa, the geology, origin of the ores etc. Ills. 3000 w. Min Wld—May 5, 1906. No. 76540.

Metallurgy.

The New Metallurgy. G. A. Denny and H. S. Denny. Considers the metallurgical question of the Witwatersrand, discussing the results obtained at the New Goch and the Meyer & Charlton mines, where the new departures have been put into practice. 5500 w. Min Jour—May 19, 1906. No. 77011 A.

Unsolved Problems in Metallurgy. Robert Abbott Hadfield. The Inst. of Civ. Engrs.—14th "James Forrest Lecture." Deals chiefly with iron and its alloys. 2500 w. Engr, Lond—May 4, 1906. Serial. 1st part. No. 76665 A.

Mica.

India Mica Industry. Ralph Stokes. An illustrated account of the Madras or Nellore mica field and its development. 2500 w. Min Wld—May 19, 1906. No. 76719.

Monazite.

Monazite Sand. C. Richard Böhm. Abstract of a paper in *Chemische Industrie.* Where known deposits are located, the method of working, exploitation, etc. 1200 w. Eng & Min Jour—May 5, 1906. No. 76543.

Nigeria.

The Mineral Survey of Nigeria. Information from the reports by Prof. Dunstan, on The Mineral Survey of Nigeria. The minerals found are given. 1200 w. Engr, Lond—May 11, 1906. No. 76766 A.

Phosphate.

Florida Pebble-Phosphate Mining. John Bannon. Describes the processes and methods of the phosphate mining industry. 2500 w. Mfrs Rec—May 3, 1906. Serial. 1st part. No. 76480.

Platinum.

How to Pan Platinum. Dennis H. Stovall. Suggestions from the experience of W. J. Wimer. 700 w. Min Wld—April 28, 1906. No. 76409.

We supply copies of these articles. See page 637.

Tin.

Tin. The Famine in Tin. Editorial discussion of the increase in price, and the falling off of the supply, and the future outlook, mining localities, etc. 2000 w. Engng—May 18, 1906. No. 77016 A.

The Tin Deposits of Alaska. Abstract of a report by Frank L. Hess, who visited and examined the prospects and development work in the York region of Alaska. 2800 w. Ir Age—May 31, 1906. No. 77030.

The Vulcan Tin Mine, North Queensland. Gives the history of a mine which has beaten the record of any lode tin mine in the world. 2200 w. Min Jour—May 19, 1906. No. 77010 A.

Uranium.

Uranium. Victor Blanc, in *Western Chemist and Metallurgist.* Describes the metal and its properties, its occurrence, determination, etc. 2400 w. Aust Min Stand—March 28, 1906. No. 76554 B.

Zinc.

Spelter Statistics for 1906. W. R. Ingalls. Statistics of this industry in the United States, showing where the ore was produced and where consumed. 3500 w. Eng & Min Jour—May 12, 1906. No. 76608.

The Lungwitz Process of Zinc Smelting. Fred W. Gordon. Describes a furnace recently put into operation at Warren, N. H., especially designed to meet the requirements of this process, and the problems in connection with its operation. 3000 w. Eng & Min Jour—April 28, 1906. Serial. 1st part. No. 76398.

Zinc Mining in New Mexico. R. W. Haddon. Describes the deposits of the Magdalena range, giving cross section, and reporting development. 1000 w. Eng & Min Jour—May 5, 1906. No. 76544.

RAILWAY ENGINEERING.

CONDUCTING TRANSPORTATION.

Railroads.

The Relations of the Railroads to the Public. R. C. Richards. Address before the Trans. Assn. of Milwaukee. Discusses things essential, the investigation of claims and complaints, improvements needed, etc. 2000 w. R R Gaz—May 11, 1906. No. 76612.

Tablet Exchange.

Whitaker's Electric Train Tablet Exchanger. Briefly outlines the mechanical and manual apparatus which has been in use, and gives an illustrated description of the new pattern invented by Mr. A. Whitaker. 1800 w. Engng—April 27, 1906. No. 76571 A.

MOTIVE POWER AND EQUIPMENT.

Air Brakes.

Brakebeams and Foundation Rigging—The Requirements from the Standpoint of Safety and Emergency. Edward B. Leigh. Presents facts showing that foundation rigging and "emergency" service, should have immediate attention and treatment. 2800 w. Ry Age—May 25, 1906. No. 76984.

Brake Tests Made at West Seneca on the "Lake Shore and Michigan Southern Railway." Report of tests made on the Westinghouse brake known as the quick-service brake. 3000 w. Bul Int Ry Cong—April, 1906. No. 76954 E.

Comparative Test of Large Locomotive Air Pumps. Reports a comparative test of the new Westinghouse compound and the New York No. 5 duplex pumps, made by the L. S. & M. S. Ry. 1800 w. Ry Age—May 18, 1906. No. 76717.

New S. F. Brake Valve. Illustrated description. 800 w. Ry & Loc Engng—June, 1906. No. 77108 C.

New Westinghouse K Triple Valve. Illustrated detailed description of the quick service triple valve and its operation. 1000 w. Ry & Loc Engng—June, 1906. No. 77109 C.

Type H. Automatic Brake Valve. Illustrated detailed description. 1700 w. Ry & Loc Engng—June, 1906. No. 77107C.

Cars.

Rapid Railway-Carriage Building. An illustrated account of work carried out in India at the Parel workshops of the Great Indian Peninsula Railway Company. 800 w. Engng—May 18, 1906. No. 77017 A.

Steel Flat-Cars for Specially Heavy Loads. Illustrates and describes recently built cars, designed to carry heavy castings and peculiar designs. The 100-ton car for the Allis-Chalmers Co.; 87-ton and 60-ton cars: Pennsylvania R. R.; and 60-ton car: General Electric Co. are considered. 2200 w. Eng News—May 24, 1906. No. 76779.

Steel Rolling Stock. George Harrison Sheffield. Abstract of a paper read before the Tram. & Lgt. Rys. Assn. Does not consider a combination of steel and timber desirable, reports condition of all-

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steel cars in long service, and discusses changes and improvements in rolling stock. 3300 w. Elect'n, Lond—April 27, No. 76567 A.

Very Heavy Capacity Flat Car. Illustrated description of a novel freight car design, built at the C. M. & St. P. Ry. shops in West Milwaukee for the Allis-Chalmers Co. It is designed for a load capacity of 100 tons, with a permissible 10 per cent overload. 1200 w. Ry & Engng Rev—April 28, 1906. No. 76403.

Liquid Fuel.

Petroleum Fuel in Locomotives in the Tehuantepec National Railroad of Mexico. Louis Greaven. Gives the results obtained by the use of liquid fuel for one year. Ills. 4000 w. Inst of Mech Engrs—March 16, 1906. No. 76666 N.

Locomotive Boiler.

Brotan Locomotive Boiler with Water Tube Firebox. Illustrated detailed description of a boiler being introduced on several foreign roads. It was designed to obviate the difficulty found with copper fireboxes and staybolts, especially when used for high pressures. 1600 w. Ry Age—May 4, 1906. No. 76535.

Locomotives.

A Comparative Test Between a Simple and Compound Locomotive. A thesis submitted for the degree of Bachelor of Science in Mechanical Engineering, University of Wisconsin. Describes tests made. Plates. Discussion. 14800 w. Pro W Ry Club—April 17, 1906. No. 76693 C.

British Locomotives in 1905. Charles Rous-Marten. A review of the designs and work. Ills. 6800 w. Bul Int Ry Cong—April, 1906. No. 76949 E.

Comparison of the Wear of Wheel Tires of Locomotives with inside and with Outside Cylinders. O. Busse. Showing the advantages of inside cylinders. Tables and Ills. 1300 w. Bul Int Ry Cong—April, 1906. No. 76951 E.

Compound Locomotives. G. R. Sisterston. Considers the things upon which the success of compound systems depend, and describes a form of this system in which there are four equal cylinders, one high and there low-pressure. 2000 w. Engr, Lond—April 27, 1906. No. 76577 A.

Conversion of the Great Eastern Decopod. Reviews the history of this English locomotive, and gives an account of the use made of it. 1200 w. Engr, Lond—April 20, 1906. No. 76450 A.

Locomotives with Special Valve Gears (Lokomotiven mit Ventilsteurerung). E. Metzeltin. Describing special gears for locomotives using piston, Corliss, and similar valves, with especial reference to the locomotives of the Hanover Machine Works. Serial. Part I. 7500 w. Zeitschr d Ver Deutscher Ing—April 28, 1906. No. 76801 D.

Norfolk & Western 4-6-2 Locomotive. Illustrates and describes the principal features of interest. 400 w. Ry Age—May 4, 1906. No. 76534.

Note on the Calculation of the Loads Hauled by Locomotives and on the Determination of the Time Required for Running in Ordinary Service. O. Busse. 2000 w. Tables. Bul Int Ry Cong—April, 1906. No. 76952 E.

Standardizing Locomotive Equipment. Describes the Standard locomotive parts adopted by the Canadian Pacific Railway. 1200 w. Am Engr & R R Jour—April, 1906. Serial. 1st part. No. 76466 C.

Superheating.

Locomotive Superheaters — Practical Difficulties in the Use of Superheated Steam. Remarks recently made by W. F. M. Goss, reviewing the early and recent developments in the use of superheated steam. 2000 w. Sci Am Sup—May 19, 1906. No. 76689.

Superheated Steam on the Canadian Pacific Railway. H. H. Vaughan. Describes the progress made during the last year in the application of superheated steam to locomotives on the Canadian Pacific Railway, discussing the results. Also general discussion. Ills. 12400 w. Pro N Y R R Club—April 20, 1906. No. 76794.

Superheated Steam on the Canadian Pacific Railway. Editorial review of the paper presented by H. H. Vaughan before the N. Y. R. R. Club. 3000 w. Am Engr & R R Jour—May, 1906. No. 76468 C.

Ten-Wheel Coupled Locomotive for Argentina. Two-page engraving and illustrated description of details of this interesting engine. 1000 w. Engng—May 18, 1906. No. 77012 A.

Train Lighting.

The L'Hoest and Pieper System of Electric Train Lighting (Die Elektrische Zugbeleuchtung von L'Hoest und Pieper). E. Wikander. A steam dynamo on the locomotive associated with a storage battery, furnishes the current for the train. 1000 w. Glasers Annalen—May 15, 1906. No. 76819 D.

The Lighting of Railway Carriages with Incandescent Gas Burners (Gasglühlichtbeleuchtung der Eisenbahnwagen). H. Gerdes. With illustrations of direct and inverted mantle burners as used in England, France, and Germany, with especial reference to the Pintsch incandescent light. A table of photometric tests is given. 3500 w. Glasers Annalen—May 1, 1906. No. 76830 D.

Trucks.

Motor Trucks for the New York Cen-

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tral Electric Service. Illustrated description of the truck adopted for the electric suburban cars, which is a departure from any type of motor truck heretofore used. 1800 w. St. Ry Jour—April 28, 1906. No. 76412 C.

Wheels.

Solid Rolled Steel Car Wheels and Tires. Peter Eyermann. Reviews the development of iron and steel wheels, the methods of manufacture, describing plants and the various types made in Europe and America. Ills. 5000 w. Ir & St Inst—May, 1906. No. 76915 N.

NEW PROJECTS.

Central Asia.

Russian Railway Schemes in Central Asia (Eisenbahnbau und Eisenbahnpläne in Mittelasien). F. Thiess. With map of the Orenburg-Tashkend railway plans, showing the political and commercial relations of the line to Persia, Turkestan, and India. Map. 2000 w. Glasers Annalen—May 15, 1906. No. 76818 D.

China.

What Railroads May Do for China. Eliot Blackwelder. Describes the methods of transportation used by the Chinese, which have remained unchanged for many generations. Ills. 2200 w. Wis Engr—June, 1906. No. 76698 D.

Moffat Road.

The Denver, Northwestern and Pacific. This new road the construction of which was brought about by David H. Moffat, is generally known as the Moffat road. Describes recent work, and the country through which the road passes. Ills. 2500 w. R R Gaz—May 18, 1906. No. 76746.

Philippines.

The Plans and Organization for the Philippine Railway System. Brief account of the plans for the proposed railway system. 1000 w. Eng News—May 10, 1906. No. 76621.

Transportation Systems and Projects in the Philippines. Lawrence E. Bennett. Mr. Bennett's second article discusses personal experiences on reconnaissance surveys in connection with railroad construction in the Visayan islands. 3500 w. Engineering Magazine—June, 1906. No. 76872 B.

PERMANENT WAY AND BUILDINGS.

Coaling.

Mechanical Coaling Plants for Locomotives (Mechanische Lokomotiobekohlungsanlagen). E. Harprecht. An illustrated discussion of modern conveyors, coaling bins, and coal handling appliances for railroads, with details from American and German practice. Serial. Part I. 3000 w. 2 plates. Glasers Annalen—May 15, 1906. No. 76817 D.

Culverts.

Areas of Waterways for Railroad Culverts and Bridges. George H. Bremner. Also discussion by James Dun, J. W. Alvord, Louis Kingman and others. Explains the method used by the writer after a number of years of experience. 21500 w. Jour W Soc of Engrs—April, 1906. No. 76929 D.

The Reinforced Concrete Beam Culvert: An Inefficient Structure. Daniel B. Lutin. Arguments unfavorable to the use of beams. Ills. 2000 w. Eng News—May 24, 1906. No. 76778.

Grades.

Ruling Grades on the Transcontinental Lines. Profiles and tables of the Harriman lines and Northern Pacific, with revised tables of ruling grades on A., T. & St. F., and the Can. Pacific. 600 w. R R Gaz—May 4, 1906. No. 76495.

Light Railway.

Light Railway on Ayrshire Seaboard. Illustrates and describes the Maidens and Dunure Light Railway, which overcame considerable engineering difficulties in its construction. It has 65 bridges, 20 viaducts, 6 culverts, and the entire length of the railway is only 19½ miles. 900 w. Engr, Lond—May 18, 1906. No. 77021 A.

Panama.

Increased Terminal Facilities for the Panama Railway. A brief account of the steps being taken to provide ample rail and water facilities for the handling of both through and canal traffic. 500 w. Eng News—May 24, 1906. No. 76780.

Rails.

The First T Rail? Engraving and account reproduced from the Morton Memorial Volume, edited by Prof. F. de R. Furman, of Stevens Inst., Hoboken, N. J. 700 w. R R Gaz—May 11, 1906. No. 76613.

Shop Efficiency.

Improving Railroad Shop Efficiency. Charles Coleman. Considers reduction in the cost of repairs without impairing the efficiency of the locomotive. 1000 w. Am Engr & R R Jour—May, 1906. No. 76467 C.

Signals.

Block Switch and Signal Systems (Blockapparate und Weichenverschlüsse). Dr. A. Tobler. Describing especially the electric block system of Siemens & Halske, as used in Vienna. Two articles. 4000 w. Schweiz Bauzeitung—April 21, 28, 1906. No. 76831 each B.

The Upward Indication of the Semaphore Arm. L. R. Clausen. Read before the Ry. Sig. Assn. Favoring the change from the downward to the upward indication for proceed, giving arguments. Ills. 2000 w. Ry Age—May 4, 1906. No. 76536.

Union All-Electric Interlocking at Elsmere Junction. Illustrates and describes an interlocking plant installed near Wilmington, Del. 2500 w. R R Gaz—May 11, 1906. No. 76515.

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Stations.

New York Central Passenger Station at Schenectady. Outlines improvements in this city to eliminate grade crossings and describes the fine new station building. Plans. 1800 w. Ry Age—April 27, 1906. No. 76402.

Pennsylvania Railroad's Terminal Station, New York City. Illustrated description of the proposed design. 1600 w. Sci Am—May 26, 1906. No. 76788.

The Pennsylvania Railroad's Extension to New York and Long Island. Plan, section, and illustrations of the new station in New York, with description. 2000 w. R R Gaz—May 25, 1906. No. 76966.

The Pennsylvania Railroad Passenger Station in New York City. Description, with illustrations, of the fine station to be built in New York City. 1500 w. Eng News—May 24, 1906. No. 76776.

Ties.

A Review of the Railway Tie Situation. Discusses the diminution in the sources of supol· tie-preserving, use of steel and concrete ties, spacing, size, life, etc. 3000 w. Eng News—May 3, 1906. No. 76479.

Tunnels.

See Civil Engineering, Combustion.

Yards.

New East Bottoms Yard of the Missouri Pacific at Kansas City. Plan and description of the enlargement and complete rearrangement of this yard. 1200 w. R R Gaz—May 11, 1906. No. 76611.

TRAFFIC.

Coal.

Great Northern Railway Coal Traffic. An illustrated account of the heavy traffic handled by this railway. 1500 w. Ir & Coal Trds Rev—May 18, 1906. No. 77024 A.

Earnings.

New York Central & Hudson River. Reviews this road for the past year, showing great growth in earnings, large progress in the work of electrifying the New York terminal, additional electric properties acquired, and general improvements. 2000 w. R R Gaz—May 4, 1906. No. 76493.

Rates.

The Railroad Rate Bill. Full reproduction of the Hepburn bill in the form in which it went into the hands of the committee. 7000 w. R R Gaz—May 25, 1906. No. 76967.

The Standard Oil Co.'s Low Railroad Rates. Gives extracts from Mr. Garfield's report in regard to discriminations made in favor of the Standard Oil Co., and some of the replies from the railroads. 1500 w. R R Gaz—May 11, 1906. No. 76614.

STREET AND ELECTRIC RAILWAYS.

Alabama.

Car House, Shops and Shop Practices at Birmingham, Ala. An illustrated detailed description of the car-housing and repair plant and its equipment. 3300 w. St. Ry Jour—May 5, 1906. No. 76529 C.

Alternating Current.

Alternating Current Track Circuits in the New York Subway. J. M. Waldron. Read before the Ry. Sig. Assn. at N. Y. An interesting description, with diagrams, showing the remarkable efficiency of this system of automatic signals. 1400 w. R R Gaz—May 11, 1906. No. 76610.

Australia.

The Freemantle (Australia) Municipal Tramways. Illustrated detailed description of the only municipal tramway in Australia. 3000 w. St Ry Jour—May 5, 1906. No. 76530 C.

Cars.

The New Cars of the South Side Elevated Railway, Chicago, and Their Equipment. Illustrated detailed description of new cars, seventy having just been built, and of their equipment. 3000 w. St Ry Jour—May 19, 1906. No. 76725 C.

The New Closed Car Adopted by the Schenectady Railway Company. An illustrated description of the interesting features of cars representing the most advanced practice. 1300 w. St Ry Jour—May 5, 1906. No. 76531 C.

Earnings.

An Aggregate of Electric Railway Earnings. Abstract of an article in the *Commercial and Financial Chronicle*, giving as far as possible a total of the gross and net earnings of all important street and electric railways in the United States. 1200 w. R R Gaz—May 4, 1906. No. 76494.

Freight.

Freight Handling Practice on Electric Railways. An illustrated article describing some of the methods of handling the business, and giving information of interest. 8000 w. Ry & Engng Rev—May 12, 1906. No. 76635.

Gasoline Cars.

The Gasoline Car for Interurban Service. F. W. Hild. Read at convention of the Iowa St. & Int. Ry. Assn. Investigates and compares the factors essential to the success of self-propelled

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cars, concluding that these cars will find a useful field quite distinct from that served by the electric system. Also editorial. 6500 w. St Ry Jour—May 5, 1906. No. 76532 C.

Grades.

The Story of the Galveston Grade Raising—From the Street Railway Point of View. H. S. Cooper. An illustrated article describing grade raising under very adverse conditions. 4000 w. St Ry Jour—May 12, 1906. No. 76644 C.

Improvements.

Improvements of the Brooklyn Rapid Transit Company. Illustrates and describes interesting work in connection with the reconstruction of this property. 1600 w. Ry Age—May 18, 1906. No. 76716.

Interurban.

Extensions and Improvements of the Terre Haute Traction & Light Company. An illustrated article describing new lines, features of the high-tension feeder system, and other improvements. 2000 w. St Ry Jour—April 28, 1906. No. 76410 C.

Line Construction.

New Material for Catenary Work. Illustrated description of a new method of construction now under trial, reporting tests. 1000 w. St Ry Jour—May 26, 1906. No. 76965 C.

London.

First London Tramway across the Thames. Illustrated description of the Vauxhall-Victoria tramway. 2200 w. Tram & Ry Wld—May 19, 1906. No. 76927 B.

Main Line.

Electrification of the West Shore Railroad Between Utica and Syracuse. Maps and description of the changes being made in this section, and the service to be rendered. Also editorial. 2500 w. St Ry Jour—May 19, 1906. No. 76726 C.

Missouri.

The St. Francois County Electric Railway. An illustrated description of a very successful line, explaining its peculiar location, and the reasons for its exceptional earning capacity. 3000 w. St Ry Jour—May 26, 1906. No. 76963 C.

Puget Sound.

The Puget Sound Electric Railway. Map and illustrated description of a third-rail line 36.5 miles long, connecting Seattle and Tacoma 1800 w. Ry Age—May 11, 1906. No. 76634.

San Francisco.

Street Railway Situation in San Francisco. An illustrated article explaining some changes proposed in reconstructing the lines destroyed by the earthquake and fire. 1800 w. St Ry Jour—May 19, 1906. No. 76727 C.

Single-Phase.

Single-Phase Locomotives and Motor Cars in Bavaria and Sweden. Frank C. Perkins. Illustrations of the locomotives used, and description of the electrical equipment and other interesting features. 1500 w. Sci Am Sup—May 5, 1906. No. 76501.

Single-Phase Railway for the Milan Exhibition, 1906. E. Fumero. Abstract translation from *L'Electricita*. Gives the chief features of this exhibition installation, which connects the two sites. Ills. 2000 w. Elect'n, Lond—May 11, 1906. No. 76757 A.

The Development of the Westinghouse Company's Single-Phase Railway System. An interesting brief review of the development. 1400 w. Elec Wld—April 28, 1906. No. 76593.

Stray Currents.

See Civil Engineering, Water Supply.

Sub-Stations.

Railway Sub-Station Design, Capacity and Location. Sydney Woodfield. Outlines a few considerations in regard to converter sub-stations, discussing types. 2700 w. Elec Rev, Lond—April 20, 1906. No. 76438 A.

Subways.

The Mersey Tunnel and the London Metropolitan Railway Electrifications. H. L. Kirker. In the first case the change from steam to electricity was made in a few hours; in the second the change-over was made gradually. This article shows the wisdom of the latter plan. 2000 w. Elec Jour—May, 1906. Serial. 1st part. No. 76702.

Subway Temperatures.

Causes for the Elevation in Temperature in Underground Railways (Die Gründe für die Temperaturerhöhungen in Untergrundbahnen). H. Kayser. A discussion of the extent to which the conversion of electrical energy acts to heat the atmosphere of underground railways; with data from London Paris, and New York. 5000 w. Gesundheit's-Ingenieur—May 12, 1906. No. 76843 D.

Switzerland.

An Interesting Swiss Electric Road. C. L. Durand. Brief illustrated description of the Fribourg-Morat-Anet single-phase line near Lake Neuchatel. 1500 w. Elec Rev, N Y—May 26, 1906. No. 76962.

Symbols.

Standard Symbols for Electric Railway Plans (Sicherheitsvorschriften für Elektrische Bahnanlagen). A report upon standard symbols by the German Electrotechnical Society. 7500 w. Elektrotech Zeitschr—May 17, 1906. No. 76861 B.

Three-Phase.

Berthoud-Thoune, Switzerland, Three-Phase Electric Road. C. L. Durand. Describes this three-phase electric road, giving several views of the locomotive used. 2800 w. Elec Rev, N Y—May 5, 1906. No. 76507.

We supply copies of these articles. See page 637.

EXPLANATORY NOTE—THE ENGINEERING INDEX.

We hold ourselves ready to supply—usually by return of post—the full text of every article indexed in the preceding pages, *in the original language*, together with all accompanying illustrations; and our charge in each case is regulated by the cost of a single copy of the journal in which the article is published. The price of each article is indicated by the letter following the number. When no letter appears, the price of the article is 20 cts. The letter A, B or C denotes a price of 40 cts.; D, of 60 cts.; E, of 80 cts.; F, of $1.00; G, of $1.20; H, of $1.60. When the letter N is used it indicates that copies are not readily attainable, and that particulars as to price will be supplied on application. Certain journals, however, make large extra charges for back numbers. In such cases we may have to increase proportionately the normal charge given in the Index. In ordering, care should be taken to *give the number* of the article desired, not the title alone.

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THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *t-m*, a tri-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the index are: Ill—Illustrated; W—Words; Anon—Anonymous.

American Architect. *w.* New York.
Am. Engineer and R. R. Journal. *m.* New York
American Jl. of Science. *m.* New Haven, U.S.A.
American Machinist. *w.* New York.
Am. Manufacturer. *w.* Pittsburg.
Annales des Ponts et Chaussées. *m.* Paris.
Ann. d Soc. Ing. e d Arch. Ital. *w.* Rome.
Architect. *w.* London.
Architectural Record. *m.* New York.
Architectural Review. *s-q.* Boston.
Architect's and Builder's Magazine. *m.* New York.
Australian Mining Standard. *w.* Melbourne.
Autocar. *w.* Coventry, England.
Automobile. *m.* New York.
Automobile Magazine. *m.* New York.
Automotor Journal. *w.* London.
Beton und Eisen. *qr.* Vienna.
Boiler Maker. *m.* New York.
Brit. Columbia Mining Rec. *m.* Victoria, B. C.
Builder. *w.* London.
Bull. Am. Iron and Steel Asso. *w.* Phila., U. S. A.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bull. Soc. Int. d'Electriciens. *m.* Paris.
Bulletin of the Univ. of Wis., Madison, U. S. A.
Bulletin Univ. of Kansas. *b-m.* Lawrence.
Bull. Int. Railway Congress. *m.* Brussels.
California Jour. of Tech. *m.* Berkeley, Cal.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Toronto and Montreal.
Canadian Mining Review. *m.* Montreal.
Cassier's Magazine. *m.* New York and London.
Cement. *b-m.* New York.
Cement Age. *m.* New York.
Central Station. *m.* New York.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Deutsche Bauzeitung. *b-w.* Berlin.

Domestic Engineering. *m.* Chicago.
Eisenbahntechnische Zeitschrift. *b-m.* Berlin.
Electrical Engineer. *w.* London.
Electrical Magazine. *m.* London.
Electrical Review. *m.* London.
Electrical Review. *w.* New York.
Electric Journal. *m.* Pittsburg, Pa.
Electrical World. *w.* New York.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electrochemical and Met. Industry. *m.* N. Y.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elektrotechnik u Maschinenbau. *w.* Vienna
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricità. *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Chicago.
Engineering. *w.* London.
Engineering and Mining Journal. *w.* New York.
Engineering Magazine. *m.* New York and London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Engineering Review. *m.* London.
Eng. Soc. of Western Penna. *m.* Pittsburg, U. S. A.
Far Eastern Review. *m.* Manila, P. I.
Fire and Water. *w.* New York.
Foundry. *m.* Cleveland, U. S. A.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. dei Lav. Pubb. e d Str. Ferr. *w.* Rome.
Glaser's Ann. f Gewerbe & Bauwesen. *s-m.* Berlin.
Ice and Refrigeration. *m.* New York.
Ingenieria. *b-m.* Buenos Ayres.
Ingenieur. *w.* Hague.
Insurance Engineering. *m.* New York.
Int. Marine Engineering. *m.* New York.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron & Steel Magazine. *m.* Cambridge, Mass.
Iron and Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland, U. S. A.
Jour. Am. Foundrymen's Assoc. *m.* New York.
Journal Asso. Eng. Societies. *m.* Philadelphia.
Journal of Electricity. *m.* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Jour. Roy. United Service Inst. *m.* London.
Journal of Sanitary Institute. *qr.* London.
Jour. of South African Assn. of Engineers. *m.* Johannesburg, S. A.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery. *b-m.* Fort Monroe, U. S. A.
Jour. W. of Scot. Iron & Steel Inst. *m.* Glasgow.
Journal Western Soc. of Eng. *b-m.* Chicago.
Journal of Worcester Poly. Inst., Worcester, U.S.A
Locomotive. *m.* Hartford, U. S. A.
Machinery. *m.* New York.
Madrid Cientifico. *t-m.* Madrid.
Marine Review. *w.* Cleveland, U. S. A.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris
Métallurgie. *w.* Paris.
Minero Mexicano. *w.* City of Mexico.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci. Press. *w.* San Francisco.
Mining Journal. *w.* London.
Mining Magazine. *m.* New York.
Mining Reporter. *w.* Denver, U. S. A.
Mittheilungen des Vereines für die Fôrderung des Local und Strassenbahnwesens. *m.* Vienna.
Motor Wagon. *w.* Cleveland, U. S. A
Municipal Engineering. *m.* Indianapolis, U.S.A.
Municipal Journal and Engineer. *m.* New York.
Nature. *w.* London.
Nautical Gazette. *w.* New York.
New Zealand Mines Record. *m.* Wellington.
Oest. Wochenschr. f. d. Oeff. Baudienst. *w.* Vienna
Oest. Zeitschr. Berg & Hüttenwesen. *w.* Vienna.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York.
Pro. Canadian Soc. Civ. Engrs. *m.* Montreal..
Proceedings Engineers' Club. *qr.* Philadelphia.
Pro. Pac. Coast Rwy. Club. *m.* San Francisco.
Pro. St. Louis R'way Club. *m.* St. Louis, U. S. A.
Pro. U. S. Naval Inst. *qr.* Annapolis, Md.
Quarry. *m.* London.
Queensland Gov. Mining Jour. *m.* Brisbane, Australia.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway & Engineering Review. *w.* Chicago.
Railway and Loc. Engng. *m.* New York.
Revista d Obras. Pub. *w.* Madrid.
Review of Reviews. *m.* London & New York.
Revista Tech. Ind. *m.* Barcelona.
Revue de Mécanique. *m.* Paris.
Revue Gén. des Chemins de Fer. *m.* Paris.
Revue Gén. des Sciences. *w.* Paris.
Revue Industrielle. *w.* Paris.
Revue Technique. *b-m.* Paris.
Rivista Gen. d Ferrovie. *w.* Florence.
Rivista Marittima. *m.* Rome.
Schiffbau. *s-m.* Berlin.
Schweizerische Bauzeitung. *w.* Zürich.
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Sibley Jour. of Mech. Engng. *m.* Ithaca, N. Y.
Stahl und Eisen. *s-m.* Düsseldorf.
Stevens Institute Indicator. *qr.* Hoboken, U. S. A.
Street Railway Journal. *w.* New York.
Street Railway Review. *m.* Chicago.
Technology Quarterly. *qr.* Boston, U. S. A.
Tijds v h Kljk. Inst. v Ing. *qr.* Hague.
Tramway & Railway World. *m.* London.
Trans. Am. Ins. Electrical Eng. *m.* New York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Trans. Inst. of Engrs. & Shipbuilders in Scotland, Glasgow.
Transport. *w.* London.
Wood Craft. *m.* Cleveland, U. S. A.
Yacht. *w.* Paris
Zeitschr. d. Mitteleurop. Motorwagen Ver. *s-m.* Berlin.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver Deutscher Ing. *w.* Berlin.
Zeitschrift für Elektrochemie. *w.* Halle a S.

CURRENT RECORD OF NEW BOOKS

NOTE—*Our readers may order through us any book here mentioned, remitting the publisher's price as given in each notice. Checks, Drafts, and Post Office Orders, home and foreign, should be made payable to* THE ENGINEERING MAGAZINE.

Radioactivity.

The Electrical Nature of Matter and Radioactivity. By Harry C. Jones. Size 5½ in. by 8 in., pp. x, 212. Price $2.00. New York: D. Van Nostrand Company.

A general study of the modern theory of the electron and its relation to the constitution of matter, expressed in plain, clear language, intelligible to the general reader. For those to whom the writings of J. J. Thomson and of Rutherford are difficult reading this modest work is to be commended, and the excellent reception which its chapters received as they appeared in the pages of the *Electrical Review* of New York, gives little doubt of the success of this reprint in book form.

The development of the study of radioactivity, and the discovery and separation of the radium salts opened a new chapter in investigations into the nature of matter, and this portion of the subject is treated by Mr. Jones in a manner at once clear and correct.

The student and general reader who desires to inform himself about these latest developments in the researches of the physicist and the physical chemist will find this little book at once scientifically correct and wholly readable and interesting, and it should find a wide acceptance in the wide circle to which it appeals.

Refrigeration.

Modern Refrigerating Machinery. Translated from the German of Professor Hans Lorenz by Thomas H. Pope, with chapters on American practice by H. M. Haven and F. W. Dean. Size 6 in. by 9 in., pp. x, 396. Price $4.00. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

This is a distinctly practical work, dealing with the fundamental principles of mechanical refrigeration in brief introduction, followed by descriptions of the construction of actual machines and their operation. Dr. Lorenz naturally deals with apparatus of continental design and make, and the majority of his references are to the work of Pictet and of Linde, to whom engineers in all parts of the world are ready to do honor. The added matter, due to Messrs. Haven and Dean, deals with distinctively American appliances, and includes some excellent diagrams showing in schematic arrangement the methods of direct and indirect expansion. The mechanism of American ammonia compression machines of leading builders is given in illustration, and space is also given to machines of the absorption type. It is well understood that ammonia machines have altogether replaced compressed-air machines for general service, but it should be remembered that the so-called "dense-air" machine of Mr. Leicester Allen still retains its position as the best type available for naval service, where, in long cruises in tropical waters, absolute independence of any external source of supply is essential.

The book contains some useful tables, and should form a valuable reference treatise for an important department of modern industry.

Tunnelling.

Tunnel Shields and the Use of Compressed Air in Subaqueous Works. By William Charles Copperthwaite. Size 8 in. by 11 in.; pp. xvi, 390; price, 31s. 6d.; $9.00. London: Archibald Constable & Co. New York: D. Van Nostrand Company.

With the increasing use of tunnels instead of bridges for the crossing of waterways by railways and other ways of communication there has been a revival of interest in methods of construction of such works, and hence the portly volume of Mr. Copperthwaite is timely.

It is generally understood that the use of the shield in tunnelling is due to the elder Brunel, and indeed, Mr. Copperthwaite states that the Brunel patent of 1818 "covers every subsequent development in the construction and working of tunnel shields." The progress of mechanical science since this first conception of the true method of tunnelling through earth has placed many additional resources in the hands of the engineer, and it is prin-

cipally of these later methods that the present work has to deal.

After reviewing the early history of shield tunnelling, from 1818 down to 1880, the author proceeds to discuss the use of compressed air in tunnelling, together with the development of cast-iron linings for tunnel work. The balance of the work is practically a descriptive account of the use of the shield in various departments of tunnelling work, including its employment in London clay, in water-bearing strata, and the construction of masonry-lined tunnels. These chapters are followed by an account of tunnelling works carried on with the use of the shield, together with data concerning the cost of tunnelling, based upon the records of executed works.

The great value of the book resides in its collection of fully illustrated descriptions of actual tunnel works constructed with the use of various forms of shields, these including such modern structures as the City and South London railway, the Glasgow harbor tunnels, the Hudson river tunnel, the St. Clair river tunnel, the Vyrnwy acqueduct, the Boston subway, the Paris Métropolitain, and similar modern works.

The data relating to costs are derived from recent works, including the Mersey tunnel, the Kingsway subway, and the work at Glasgow and the Sarnia tunnel under the St. Clair river. In an appendix there is given a chronological list of events relating to shield tunnelling, followed by a list of English patents from 1818 to 1904.

The book is a most valuable record of data of recent construction in tunnelling, and will doubtless become a standard of reference for engineers engaged in this increasing line of work. It is hardly to be expected that the book would contain information about the tunnels at present under construction for the Pennsylvania railroad under the Hudson river and the East River at New York, but information about these latest structures is attainable in the current technical journals, so that the earlier work can readily be supplemented and brought down to date in this manner. Otherwise it forms a valuable account of an important department of engineering work, and one which is doubtless destined to possess increasing interest as surface lines of municipal communication are replaced by underground railways. The congestion which is destined to increase in many of the great cities can only be met by the construction of subways, to which electric traction is especially adapted, this means of relief also including release from the difficulties involved in surface hauling, so that tunnel construction appears to be a department of engineering work which is destined to grow in importance in the near future, and the present work is especially timely in this respect.

Turbines.

Steam Turbine Engineering. By T. Stevens and H. M. Hobart. Size 6 in. by 9 in.; pp. x, 814. Price, 21s., $6.50. London: Whittaker & Co., New York: The Macmillan Company.

The great interest which is felt in the development of the steam turbine appears in the growing mass of literature concerning its design and construction. The earlier accounts of the modern machines appeared in the pages of the technical journals, followed by the books of Stodola, Neilson, Gentsch, and others, and now we have the present volume, which is of interest and value mainly because of the very full account which it gives of actual installations, their performances, and their recorded operative costs. Other authors have gone deeply into the thermodynamics of the turbine, the proportions of nozzles, the form of buckets, and the constructive details of various parts of the machine, but the authors of this book rightly believe that there is room for a treatise of the subject from the standpoint of the purchaser and user. The former is deeply concerned in the matter of first costs, while the latter must consider both steam consumption and maintenance. Both are vitally interested in methods of estimating the relative total costs and economy of complete projects in which, on the one hand, steam turbines, and on the other hand, other types of prime movers are employed. It is these aspects of the question which are often overlooked by designers and builders of such machines, and hence a work devoted to this side of the subject is to be welcomed.

The book starts in at once with a discussion of installation cost data, followed by chapters devoted to the leading types, with illustrations of construction, diagrams of performance, and data of operative costs. Comparisons are made of the performance of turbine and piston-engine plants, illustrations being given of complete installations, the whole forming a collection of operative data seldom found in any department of engineering work.

The subject of marine steam turbines is given a very full chapter, and the work concludes with a bibliography, including the principal articles in the technical press from 1888 down to, and including 1905. The book contains many useful tables, both in the British and metric systems, and is provided with a very full index.